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WHAT IS A DIATOM?

A LECTURE

BY CHARLES F. COX.

(*Delivered December 18th*, 1891.)

A few years ago, one of the newspapers of this city poured forth most biting sarcasm upon the presumably impractical and altogether useless system of education pursued at the College of the City of New York, because upon its annual examination papers there had appeared the question which I have adopted as the title of this lecture.

Although it is not at all likely that my words will ever reach the editor who put forth this ignorant plea for a shallow utilitarianism, I have felt, ever since I read his peppery article, that I should like to harp upon the theme for which he expressed his bitter disdain. Not because the summit of wisdom is attained when one knows what a diatom is, but because I believe that even yet some good may be done by insisting upon the value there is in pure science. The editor with whom I thus take issue, if he ever was a college student, probably acquired his "education" in the days when there was no place in the curriculum for any science that went below the glittering surface of knowledge. But there has been a great change in recent years. Not only is science more *taught*, but *more science* is taught; and, along with the

improvement that has taken place in educational methods, has come an increased appreciation of the unconvertible products of learning,—those intellectual residua which no one expects to turn into bread and butter. The world is finding out that truth, like virtue, is its own reward. But, since knowledge is spreading with tremendous rapidity, and no man can hope to cultivate the whole length and breadth of even one department, he who would be truly learned must dig deep at a single point. It is an old saying, I believe: "Not he who knows many things, but he who knows much, is the wise man."

Now, I fully appreciate the fact that a knowledge of the habits, structure, and systematic position of the diatoms is not a *necessary* part of any man's intellectual equipment. Even scientific specialists, whose field of work includes this class of objects, manage to get along very well with hardly more than superficial information as to their appearances and characteristics, while men who pursue the study of these minute wonders with more than ordinary persistency and enthusiasm have come to be known by the half-contemptuous title, *diatomaniacs*. I am not particularly anxious to inoculate new victims with their mania, but I shall be glad if, under cover of a presentation of a few of the questions which engage their attention, I am able to promote interest in the general subject of microscopical research. I believe it will be found that a study of this one family of very lowly beings will bring before us most of the leading problems of biology, and perhaps some of those of physics, besides; and I shall be disappointed if, around the nucleus which my subject supplies, I fail to gather a body of fact and speculation the contemplation of which will prove both entertaining and stimulating.

I think there is no material attribute of which science justly takes as little account as it does of mere size. All immeasurable things seem great, whether they are immeasurably large or immeasurably small; and in the same way all inscrutable phenomena are awe-inspiring and overpowering. Whether we look upwards and outwards, through the telescope, at the numberless revolving orbs of the universe, or downwards and inwards, through the microscope, at the myriad active plastides of an organized creature, the same or similar questions ultimately present themselves for solution, without regard to the prodigious size and

almost infinite sweep of the one class of objects, and the infinitesimal dimensions and limited range of the other. Of what significance are such magnitudes and distances as we can apply our rules to, when neither the telescope nor the microscope has penetrated to a final boundary? The fact is, we are overwhelmed by the futility of our effort to follow out in imagination an endless series, whether we look in one direction or turn about and look in the other.

The familiar identification of "the law which moulds a tear" and that which "guides the planets in their course," may be paralleled in very various similitudes throughout nature, and the fact that an object of investigation is minute in size, or comparatively simple in structure, does not necessarily render the primal causes of its being and actions any more easily discernible than they are in the case of that which is grand and complicated. On the contrary, complexity and multiplicity of parts have a tendency to appear self-explanatory. Thus our own highly developed body, with its numerous correlated and co-ordinated organs, is regarded as less mysterious than is the apparently undifferentiated and organless rhizopod, a seeming amorphous sample of the so-called basal "life-stuff." So, too, the giant steam engine, which impresses us mostly by its nearly irresistible power, never appears as wholly inexplicable in its operation as does the simple living current of protoplasm circling in a microscopic cell of Chara or Anacharis. In reality, the vaster and more complex a mechanism is, the more points it presents at which we are able to see the immediate connection of cause and effect, and in following back from one of these points to another we fancy we are explaining the whole *modus operandi*. We realize the essential mysteriousness of the matter only when we reach an effect without an obvious cause, as we are sure to do if we pursue the subject persistently and deeply enough.

Thus all thorough study and research end, as they begin, with a question. The interrogation-mark is, after all, the symbol of the highest and latest human wisdom. My lecture, therefore, if it pushes deep enough, is likely to close, as it opens, with the inquiry: *What is a Diatom?*

Meanwhile, however, we may perhaps move our knowledge a link or two along the chain of queries which constitutes the sci-

ence of the subject, even if we are unable to solve our problem in its entirety. By way of accomplishing what we can in this direction, it is necessary to begin by procuring specimens of the things we propose to investigate. Fortunately they are not difficult to obtain. In fact, they are amongst the most plentiful of all objects, though not ordinarily within the range of our unaided sight. To him who has access to running brooks, quiet ponds, or the greater lakes, a range of several hundred species or varieties is open. To the explorer of brackish estuaries and the deep salt sea, other hundreds offer themselves. To the one who can dig into the extensive deposits of their fossil remains, still other hundreds present their interesting forms. But even to us who dwell within the barren walls of a great city an unstinted supply of certain kinds is always close at hand, for the simplest of filters applied to a Croton-water faucet will, in a few minutes, furnish at least a half a dozen species; and this will be our most convenient source of supply.

If we take the product of our rude filter and place dippings from it under the microscope, we shall at first experience some embarrassment because of the multiplicity of objects presented to our view. There will be an abundance of sand and other amorphous and inorganic substances, and amongst these are likely to be scattered fragments of leaves and stems of exogenous plants, bits of linen, cotton or woollen threads, and various other articles of extraneous origin. Prominent, however, because of their bright color and considerable size, will appear the long jointed tubes of a few of the thread-like aquatic weeds, while deep down through the film of water we shall discern two similar and yet somewhat different sorts of diminutive bodies, which are sure to fasten our attention by their very pretty and symmetrical forms. The one kind is of a deep green color, the other of a thin reddish or brownish-olive hue ; and both will exhibit some differencing of their internal substance into denser and more attenuated parts, with here and there open, oily-looking spots. The dark green bodies appear as single capsules, narrowed, if not pointed, at each end, and floating free or else as loose aggregations of similar flattened cells, forming either rosettes or lace-like mats of various patterns. The brownish bodies will be found either as narrow rods, laid side by side in long bands, or joined

to one another by their corners so as to form zigzag lines, or else as disconnected individuals with a very striking resemblance in shape to miniature skiffs or boats. If we make use of some other source of supply than our Croton-water faucet, we may obtain a much greater variety of forms in both the classes of objects referred to, though we shall not fail to notice a certain parallelism in the morphology of the two families, which may easily cause us to think them but one. They are, however, quite distinct, as we shall see. Those forms which I have spoken of in this particular case as decidedly green in color (although this is not a decisive characteristic throughout the family) are known as *Desmids*. Those which I have described as being of a brownish hue are *Diatoms*.

But now, if we look more closely at our desmids and diatoms, we shall discover that the latter have a very rigid, hard, and almost indestructible carapace or shell, while that of the former is hardly more than a stiffened membrane which is with difficulty discerned at all. In the diatoms the enclosing case will prove to be a solid deposit of nearly pure silica: but in the desmids it will be found to be a semi-flexible film slightly infiltrated with carbonate of lime. This is an important distinction, which forms the basis for a sharp separation of the two groups of forms. As regards the particular specimens we are supposed to have under immediate inspection, however, we shall by this time have observed a difference which to most minds will constitute a clearer demarcation than could be established by any other criterion; and that is that our desmids are apparently quite passive, while the little boat-shaped diatoms actively glide about with a seemingly well-defined purpose.

You will need to abstain from generalizing too far and too fast in this connection, for all diatoms do not possess this power of locomotion, since not only are some of them united to one another, as we have seen, but many sorts are attached to plants and other fixed objects, although the theory has been advanced that all diatoms are, at one time or another, free and migratory. On the other hand, while desmids are never permanently anchored, locomotion is not a prominent characteristic of even the solitary forms, because, while it is pretty general throughout the group, it is too slow to attract attention, and, when observed, has not that

appearance of voluntariness which is exceedingly striking in the movements of the free, boat-shaped diatoms. When you have a specimen of the latter under your microscopically-aided eye, you will see it slide over the bottom of your artificial pond without discernible machinery but with very appreciable force and considerable speed. If it meets an obstruction which is not too large, it pushes it aside, but, if too heavy, it halts a few seconds and then reverses its invisible engine and changes its course.

Upon seeing this operation for the first time, one inevitably jumps to the conclusion that he is witnessing the exercise of what, in the highest orders of creatures, we call volition. But again we need to restrain ourselves. Already this microscopic vessel,—perhaps not more than the two-hundredth of an inch long,—has brought us a freight of problems as big as the world! What *is* this diatom? Is it really a living thing? What is the criterion of vitality,—what is life? If the diatom is an organism, to which kingdom of animate beings does it belong? And is there a fundamental and absolute difference between animals and vegetables, and, if so, what is it? When we have disposed of these weighty questions it will be time enough to approach that other great mystery,—the physical basis of mind,—as Alfred Binet has attempted to do in his essay on "The Psychic Life of Micro-Organisms."

Of all the struggles through which scientific progress has been accomplished, none is more interesting than the never-ending conflict of opinion which has raged around the definition of life. There is nothing about which ignorant and thoughtless people are more certain than about their ability to distinguish between that which is alive and that which is dead. On the other hand, amongst the learned and the wise this is one of the unsettled matters which as yet hold out no promise of being set at rest. To the uninformed self-motion is the conclusive evidence of vitality;—that is to say, motion not having an evident cause external to the body moved. "It moves of itself, therefore it is alive," is the offhand expression of the popular judgment.

But if visible motion ever furnishes a trustworthy test, it is under very strict conditions and in a very limited domain. That it supplies no line of demarcation between the organic and the inorganic worlds was made known in 1826 by Robert Brown's

discovery of the ceaseless activity, under favorable circumstances, of probably all small particles having a diameter of less than the one-five-thousandth of an inch. This phenomenon, which has come to be known as "the Brownian movement," but the cause of which has never been determined, might easily deceive the inexperienced observer into thinking he had under the microscope a lively colony of animalcules when, in fact, he might be looking at almost any finely-divided insoluble substance,—even, perhaps, at iron filings. In 1874 I rubbed up in water a little gamboge, which I confined in a hermetically-sealed cell, and which, for more than fourteen years (as long as the cell remained intact), was brought out periodically to illustrate the fact that "things are not what they seem." Numerous other illustrations of this uncertainty of appearances might be drawn from things in sight and above sight, as well as beneath sight ; and it is well to remember in this connection that, broadly considered, motion is an attribute of every form and condition of matter, great or small, simple or combined, inorganic or organized.

All forces are now regarded as modes of motion, and, since the abandonment, some fifty years ago, of the theory of a vital essence or principle,—which had itself superseded an earlier doctrine of a vital entity or substance,—science has become accustomed to correlating the vital forces with the physical and the chemical, and to looking upon all phenomena as different manifestations of a common activity, varying only in intensity and range.

This is, after all, merely a return to a method which has prevailed at often-recurring periods,—the method of reducing all scientific facts to a common denominator. No phase of philosophical thought is more persistent than this tendency to find a fundamental unity underlying all diversity,—to clear away perplexing mysteries by diffusing them through a universal solvent. Thus biology has had to pass several times through a period in which the best intellects and the most serious workers were devoted to a search for an elixir of life,—something which should embody the principle of creative power. These endeavors, however, like the efforts of the alchemists of old, have always ended in philosophical abstractions rather than in a concrete result upon which science can lay its material hand.

This proved to be the case with the notion which Coleridge worked out in his "Theory of Life,"—a vein which many philosophizers had followed before his time and one which some occasionally dig at even now. The idea they seek to develop is that which Herbert Spencer himself expressed in one of his early essays, when he said: "The characteristic which, manifested in a high degree, we call Life, is a characteristic manifested only in a lower degree by so-called inanimate objects."

But this conception was too indefinitely homogeneous to rest quietly in Mr. Spencer's mind. We all know how it subsequently evolved into the famous definition, given in his "Principles of Biology," namely, that life is "the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external co-existences and sequences." This idea is very different from the ideas which were previously entertained and which various authors had attempted to record in brief sentences and even single words. Bichat's definition of life was: "the sum of the functions which resist death." De Blainville's was: "the twofold internal movement of composition and decomposition at once general and continuous." Lewes's was: "a series of definite and successive changes, both of structure and composition, which take place within an individual without destroying its identity." All of these definitions are open to serious objection, as has been shown very clearly by Dr. Drysdale in his inaugural address as President of the Liverpool Biological Society. He himself proposes, as being most closely in accordance with the latest development of the protoplasmic theory, the definition of life as "the consumption and regeneration of protoplasm in co-operation with external conditions, pabulum and stimuli," which, however, he thinks may be further simplified as follows: "Life is the interaction of protoplasm with the environment."

Now, all definitions are true only from fixed points of observation. They vary both in time and in space,—that is, as we pass from the knowledge of one period to that of another period, or as we pass from the domain of one sort of learning to the domain of another. Thus, while Dr. Drysdale's definition of life seems to suit pretty well the present knowledge of a worker in the microscopical realm, I can see that it may be very unsatisfactory to the biologist in a broader field and that it may be totally inadequate

to the wants of the investigator of the future, whether in one field or another. For our present purposes, however, it may be good enough, and if we apply the test which it furnishes to our little diatom, we shall find that we have under consideration a really living thing.

This conclusion of course assumes that the diatom possesses, in addition to the hard framework or shell, of which I have already spoken, a body of plastic substance called protoplasm. This, upon close examination, we easily learn to be the case. Very simple methods of investigation show that every frustule (as each individual cell is called) is in reality a glass box enclosing a semifluid, nearly transparent, but somewhat granular material, containing, besides the oily-looking spots or vacuoles to which I have before referred, more or less of a yellowish or brownish-green substance, which gives its general color to the whole organism. There is reason to believe that the semi-fluid material also forms an enveloping layer on the outside of the siliceous carapace of all diatoms, and in many instances a similar glycerin-like matter permanently encloses a whole colony of otherwise separate frustules, which passively spend their existence within its restraining grasp. Now, chemical tests disclose the fact that the colloidal mass within the transparent valves is composed of carbon, oxygen, hydrogen, and nitrogen in proportions and relations which characterize an organic substance, and a great number of converging facts, derived from long-continued observation, go to prove that this substance is the seat of all the changes, chemical and physical, which constitute what Dr. Drysdale calls the "interaction of protoplasm with the environment." In other words, it is the consumption and regeneration of this substance "in co-operation with external conditions, pabulum and stimuli," which make up the sum of phenomena embraced in this humble creature's life-history. We therefore conclude that this substance is protoplasm.

It is through and by this protoplasm that the diatom responds to the influences of heat and light, that it receives and assimilates its food, that it moves from place to place as we have seen the boat-like specimen in the Croton water doing, that it grows and reproduces its kind. It was because of its agency in these matters that Prof. Huxley called protoplasm "the physical basis of life," though its name really means "primary formative

matter," and Beale's designation of it, bioplasm, more definitely expresses the idea of its being a *life* plasma.

But the fact that the living portion of the diatom consists in the main of protoplasm, is not enough to enable us to answer the question whether the diatom is an animal or a vegetable, since protoplasm is common to both kingdoms of the organic world and enters into the composition of all animate things, high and low. Not only is it apparently the essential part of the desmid, the diatom, the amœba, and the rest of the protophyta and the protozoa (the so-called "lowest" living creatures), but it appears to be the seat of all vital action in the water-weed and the fish that swims beside it, the shrub and the reptile that crawls at its root, the tree and the quadruped that enjoys its shelter,—even in man himself, who excels all and rules all. In Nitella, Valisneria, or Anacharis you may see the colorless current circling in every cell, building and unbuilding with a chemistry beyond our ken, and in all the higher animals it seems to be the matrix in which are fashioned the tissues and the bones, the source also of the contractility of the muscles and the sensibility of the nerves. In your own warm blood you will find protoplasm, in the form of the "white corpuscles" which creep and crawl with an activity and independence quite mystifying to the observer, but doubtless with a useful and important purpose, if we only knew what it was; and if you could look into your own wondrous brain you would probably find protoplasm in some way underlying all consciousness and thought.

But when I thus talk of protoplasm, I use the word as a generic term, in the same manner as I should speak of tissue or muscle. There is a difference between the ideal, or philosophical, protoplasm, and the real, or physiological, protoplasm. The philosophers have created for themselves, by an *a priori* process, a substance which is absolutely homogeneous and structureless, and which is identical in composition and attributes throughout the whole realm of animate nature. On this hypothetical basis they have undertaken to erect a monistic system in which animals and plants actually arise from the same root-stock and are really quickened by the same vital stream. I have no preconceived dislike to such a theory, if it can be proved true; but, unfortunately, the inductive methods of physiology do not confirm this deductive con-

clusion of philosophy. The reason of course is that philosophy has assumed false premises. There is in fact no one protoplasm ascertained to be common to all living things. The latest science proves conclusively that what Huxley laid stress upon as the physical basis of life, and Beale staked his theory of "vital power" upon, as the true "germinal matter," are not structureless colloids, alike wherever found, but that they are complex in structure and various in chemical composition,—in short, that there are probably as many different protoplasms as there are organisms.

How, then, are we to tell whether our diatom is animal or vegetable? Here is another of those points at which ignorance has been accustomed to think itself wise, but where wisdom has come to admit itself ignorant. Prof. Huxley set forth the situation of this matter most admirably in his lecture entitled "The Border Territory between the Animal and the Vegetable Kingdoms," and there has been no essential change in the case since he therein stated it. Naturalists had been in the habit, from the days of Cuvier, of relying upon four proofs which they considered conclusive of the animal nature of any organism. These were (1) the possession of an alimentary cavity, (2) the presence of muscles for locomotion and of nerves for sensibility, (3) the existence of nitrogen as a constituent element of the body-substance, and (4) the exercise of the function of respiration,—the absorption of oxygen and the exhalation of carbonic acid. But all of these distinctions have been shown to be subject to so many exceptions as to destroy their value as tests. For example, the reproductive bodies set free by certain algæ, which, from their resemblance to animals, have been given the name *zoöspores*, are as active in their movements as any animalcules, and to all appearances exercise quite as much volition. They also appear to search for food and are provided with internal spaces which Ehrenberg, not altogether unreasonably, took to be stomachs, and upon the existence of which he founded his family of the *polygastrica*, a division of the animal kingdom in which he included, with numerous zoöspores, not only true animalcules but also all diatoms. It is not yet certain that zoöspores are really destitute of a digestive system, and, as to muscles and nerves, they are certainly as well endowed as are the lowest known animals. On the other hand, many para-

sitical animals, and the males of most rotifers, or wheel animalcules (which occupy a comparatively high position in the scale of organization), have no digestive apparatus whatever, as far as can be discovered, while the fresh-water hydras and many other lowly animal forms receive their food as well at one point as at another, and in fact perform the act of digestion throughout the whole body. So Cuvier's and Ehrenberg's principal criteria of animality have broken down and disappeared from the domain of biology, and along with them have gone all the other old-time tests. Darwin's researches on insectivorous plants gave a fatal blow to the theories built upon sensitiveness and response to stimuli, on the power of complex motion directed to a definite end, and on the appropriation and assimilation of organic food.

For a long time the existence of chlorophyll in an organism was deemed conclusive evidence of its vegetable nature, for chlorophyll is what gives the green color to all the higher kinds of plants, and chemistry had shown that chlorophyll was the seat of those operations which separated the carbon from carbonic acid and built it into the woody substance of the plant, and carbon was regarded as belonging strictly to the vegetable world. But, alas for consistency, it was found that some plants do not contain chlorophyll, and, still worse, that there are certain undoubted animals which are possessed of it and that in their economy it performs the very same duty that it performs in plants.

I would not have it understood from all this that there is a border country into which organisms may wander from the animal and the vegetable kingdoms and therein lose all definite character and all trace of their origin; or that, by crossing this no-man's land, the former inhabitants of one domain may become thoroughly naturalized in the other. There is no such magic about this curious region. Its perplexities and uncertainties mainly grow out of the fact that it is the place where the frayed-out edges of the two kingdoms come together to form a hazy mixture of intermingled fringes. The ravelled threads have not necessarily lost their identity, though we are unable to disentangle them. While there are many living forms which at present cannot be definitely classed with either animals or vegetables, experience leads us to think that, in most cases, if we could trace out the complete life-histories of the doubtful organisms occupying this

middle ground, we should find their lines of relationship leading pretty clearly in one or the other direction. At any rate we should learn that what had an animal origin continues as animal and ends as animal; that what began as vegetable remains vegetable to the last;—both completing sooner or later a circle of existence limited by a law of inheritance of which we have not as yet found the secret.

The difficulty with this matter, as well as with the subject of vitality, is that we look for single distinguishing signs when we ought to take into consideration a whole series of phenomena at once. Thus life would prove to be not an entity, an essence, or even a principle, but rather *a process*. In like manner, the criterion of animal life, as distinguished from vegetable, would not be found in assimilation, sensation, self-motion, or any other one thing, but in a group of actions and attributes, by their sum-total turning the scale to the animal side.

In his interesting discussion of this topic, Prof. Huxley reaches the conclusion, now generally accepted, that the nearest approach to a definite dividing line is in the fact that the plant can make the peculiar nitrogenous substance called protein, while the animal must get it from the vegetable realm. "Thus," he says, "the plant is the ideal *prolétaire* of the living world, the worker who produces; the animal, the ideal aristocrat, who mostly occupies himself in consuming."

But even the distinction here attempted needs to be fortified by other considerations when we come to particular instances, since Darwin has shown that certain of the higher plants eat, as well as manufacture, protein, and the same fact has been demonstrated as to fungi and many other thallophytes. There is, however, no reason to suppose that diatoms are eaters, although the wanderings of the free forms have every appearance of being directed in search of food. But to the best of our knowledge and belief their quest is for inorganic pabulum, if, indeed, it has direct relation to food at all and is not, after all, merely one of those curious modes of dispersion with which we are familiar amongst spores and seeds. As far as we know, the diatom protoplasm has no proclivity for cannibalism, as all animal protoplasms seem to have. Taking this negative quality for what it is worth, and adding it to the general sum of the diatom's other characteristics which com-

mon sense somehow recognizes as belonging to the vegetable kingdom, we arrive at a decision that the object of our consideration is a plant and not an animal.

This may not be a strictly scientific way of settling the question, but how else are we to dispose of it when so great a stickler for inductive methods, as Prof. Huxley, declares that the latest information on this subject tends to the conclusion "that the difference between animal and plant is one of degree, rather than of kind; and that the problem whether, in a given case, an organism is an animal or a plant, may be essentially insoluble"?

Having made up our minds that diatoms lie within the boundaries of the vegetable kingdom, we shall have no difficulty in referring them to that sub-kingdom which includes all non-vascular, or, in other words, leafless and rootless plants,—called *thallophyta*. In this sub-kingdom is the well-known class *Algæ*, which embraces all aquatic thallophytes, and to which therefore the diatoms must belong. Indeed, they constitute a very important sub-class of algæ, which derives its name from them,—the *diatomaceæ*.

The diatomaceæ themselves get their name from the Greek word *διατομος*, which means *cut through*, *cut in two*, or *cut up*, and which was applied to them with reference to the bead-like manner in which the individuals of many genera cling together in fragile strings. These are the forms which earliest attracted attention, and which in common language were described as "brittle-worts," an appellation intended to connote the same characteristic as is denoted by the Greek name. The latter possesses additional appropriateness because of the fact that each frustule is bivalvular in structure, and from the still further fact that one of its modes of reproduction is a cutting in two of every parent cell to form twin descendants. When this process continues through several generations without an actual separation, the result is a loosely united filament, fillet, or flabel, according to whether the parent form was round, square, or wedge-shaped. The string, band, or fan thus produced will be *cut into* at regular intervals and may easily be *cut up*, or broken up, by the application of any external force.

Reproduction by self-division is not at all peculiar to this sub-class, nor even to the vegetable kingdom. Animals, as well as

plants, commonly multiply by simple fission, and amongst the true infusoria, or animalcules, the operation is so rapid that, in some genera (as, for example, the vorticellæ), one may witness within an hour the complete bisection of a single vigorous creature into two lively counterparts. The process in the plant-world is generally much slower, but it passes through essentially the same steps and may be traced with equal clearness and certainty. In fact, at their foundation all modes of reproduction are but forms of fission,—the division of one into two or more,—and the ultimate nature of the process is not changed by the fact that the resulting two are often so dissimilar in size and other attributes that we feel bound to regard one as the parent and the other as the offspring. In other words, it is none the less fission because it takes the form we call budding.

I have a strong liking for the system which classifies this whole matter under the two heads, continuous gemmation and discontinuous gemmation,—the former covering all cases in which the bud or fruit remains permanently attached to the parent stock, and the latter those cases in which it is set free to shift for itself. Examples of continuous gemmation are found among those non-vascular algæ which are nevertheless multicellular in habit, as well as among those animals whose individuality is wholly subordinated to a commensal mode of existence. Under the first head we have such lowly plants as the net-like hydrodictyon, the thread-like spyrogyra, and the chain-like diatoms; under the second we find all such perplexing creatures as the sponges, corals, and zoöphytes.

Continuous gemmation gives rise to very interesting and complicated relations which involve another insoluble biological puzzle,—as to what constitutes an individual. When one regards the cell-units, with their circumscribed and apparently complete cell-functions, he is disposed to credit them with the real individuality; but when he looks to the mutual interdependence which usually exists between the cells which retain a physical connection with one another, he inclines to expand the idea so as to include all the members of any communal aggregation, if he does not stretch it still further, as some authors do, so as to cover all the products of fission or gemmation within a continuous series, whether remaining united or not. In such cases, however

as those of the filamentous and flabellate diatoms, in which there is no absolutely necessary connection between one cell and another, and where there is no known reason why any single frustule would not go on in the performance of all essential functions if it were entirely separated from its sister cells, we seem to be quite justified in regarding the type as physiologically unicellular, even though the anatomical units are not always physically solitary or free. There is at least no evidence that those diatoms which are found within a *thallus* (as already mentioned) have anything more than a mechanical connection with one another, and vital independence is after all the best test we have of their actual individuality.

For some as yet unexplained reason, multiplication by fission sooner or later results in an exhaustion of the vital powers, which would lead to a rupture of the line of descent if it were not for the introduction at this point of the phenomena of conjugation, which, in some mysterious way, give fresh impetus to the reproductive energy. This new departure is brought about by the merging of two organisms into one and the formation from their combined substance of an enlarged and reinvigorated mother-cell, called a zygospore, which becomes the progenitor of a new family, descending from it by the original process of self-division. But the exact nature and office of the zygospore are enveloped in great uncertainty, which has been deepened rather than elucidated by a good deal of hasty inference which has been put upon record as established fact. Thus, it has been asserted that two zygospores sometimes arise from a single union, and also that conjugation results in the production of a "sporangial frustule," which undergoes in itself a segmentation which ends in the formation of true spores, which are set free by the rupture of the containing envelope and which then establish large numbers of new centres of diatom-life. These and other reputed phases of the reproductive process rest upon observations which are more than doubtful, but even if they shall be at last accepted as true, the entire matter will still be found to be reducible to modes of gemmation, either continuous or discontinuous.

As has been indicated already, the medium through which the vital forces work out their wonderful effects is the internal protoplasmic substance of the diatom, otherwise known as the endo-

chrome. It is this mysterious, active matter which, with a chemistry peculiar to itself, gathers up the soluble silicates from the water in which it lives, and builds them into its enclosing tissue or film to form its beautiful glass-like shell, and it is this same restless and expanding endochrome which, in multiplying itself by binary subdivision, pushes apart the valves of its containing case and, as fast as it thus gains room, constructs in the enlarging chamber new siliceous walls encasing the nascent pair of diatoms into which the growing frustule is divided. Thus it comes about, by imperceptibly fine transitions, that the crystal jewel-case and its delicate, living contents are, at one and the same time, transformed, by the natural magic in which the microscopical world abounds, into duplicate descendants hardly distinguishable from each other and closely resembling in every particular the parent form whose individuality is lost in the new units which have taken its place. This remarkable operation is going on every minute, and in countless centres of vital activity throughout the whole world, and of course it has been going on for numberless ages since the first diatom or its evolutionary progenitor made its appearance in the waters of the earth. There is exceedingly strong probability too that this dividing and subdividing will continue during all time to come; and so, whether we regard the matter retrospectively or in anticipation, we perceive a practically endless chain of diatom-life, through which threads an unbroken line of protoplasmic succession. In the higher orders of living things one generation passes entirely away and the following generation sooner or later becomes the head of the family or race. But amongst the lowest creatures, when one bit of animate jelly becomes two bits of animate jelly, the distinction of generations cannot be preserved and there is a nearly strict continuity and identity throughout the genetic line from beginning to end. In other words, the stream of living matter flows on forever, its component substance never disposed twice in exactly the same manner, yet always essentially the same stream. Some portion of it undergoes chemical transformation from time to time, and the waste is supplied by acquisitions of new material, as the water of a river is evaporated and replenished, but the identity of the stream is, in a sense, never lost. On this conception has been erected an ingenious theory of immortality, in which the ideal

protoplasm figures, not quite accurately, perhaps, as the one material thing which is the same yesterday, to-day, and forever.

I have already said, however, that the ideal protoplasm of the philosophers and the actual protoplasm known to the biologists are two very different matters. The former, you will remember, is a colorless, homogeneous, structureless colloid, like glycerin; but the veritable thing which we are able to get under the microscope is always much less simple in appearance and is generally complicated with other substances. The endochrome of the diatom, for example, is usually spoken of as if it were wholly protoplasm, when in fact it is made up of soft parts and harder parts, transparent spots and nearly opaque spots, liquids, semi-liquids, and solids, together with the green chlorophyll and a brown coloring matter, and, in addition to the vacuoles of which I spoke some time ago, veritable oil drops, which are supposed to correspond with the starch-granules of the higher plants. Under the microscope the endochrome therefore looks like what it really is,—a mixture of numerous substances of various colors and consistencies, with, however, a tendency to greater and greater density towards a certain central spot which has always been an object of great interest to investigators. This area of condensation is known as the *nucleus*. Formerly undue mystery was attached to it, as the supposed shrine of the vital spirit. Here, it was fancied, life had been traced to its ultimate hiding-place. It was believed that there could not be a living unit without its nucleus, and, as the anatomical unit was taken to be a closed vesicle, called a cell, all living creatures were, in the last analysis, reduced to a single cell with its nucleus, or to an aggregate of such cells. But by and by it was found that the enclosing vesicle was no essential part of the ultimate unit,—that in fact it was a product of the enclosed protoplasm and, being later in time, must be subordinate in importance. Then the cell-theory was modified into the protoplasm-theory, and the unit became a lump of protoplasm with its nucleus. But, just as the increasing power of the telescope has compelled a change in our ideas of the nebulæ, by making wha were formerly mere condensations of light resolve themselves into numberless clusters of universes and worlds, with their own centres of force and activity, so the improvement of the microscope has forced upon biologists a recasting of their theories of the

nucleus, by enabling them to resolve it into component parts, and to show that within the so-called nucleus a still deeper nucleus exists, and another within this, and so on down, until the powers of the lens are exhausted and the observer can discern at last only a "germinal spot," or point, where somehow, but he knows not how, vital energy emerges or at least manifests itself.

Further than all this, it has been discovered that numerous organisms exist, in which it is impossible to make out anything at all corresponding to this specialized region; and so the sweeping generalizations which were not long ago accepted, as to the absolute necessity of a nucleus to every living unit, have been completely discredited. Still, a great deal of attention is bestowed upon it in such organisms as do possess it, because in such cases it is evidently the seat of greatest vital activity.

In the diatoms, the first indication we have that self-division is about to take place is the appearance of a sort of uneasiness within the nucleus and the formation of a constriction about the middle of the endochrome. This is at the beginning a mere indentation of the outline, but it gradually deepens and deepens until it finally results in the cleaving of the endochrome in twain. It is one of the most impressive sights a man can witness,—this kneading and moulding of the primal matter of a living organism by an invisible agency, under whose mysterious excitement it trembles and surges and at last rends itself apart. One can hardly hope to come nearer than this to the actual first cause of the organic world.

Having once seen this manifestation of efficient energy within the diatom-shell, we shall not much wonder that the free frustules move from place to place. We may, however, entertain a lively curiosity as to the direct means by which their locomotion is accomplished, although, in the present state of knowledge, I am sorry to say, that curiosity cannot be satisfied.

Amongst the lowest known living things two modes of locomotion prevail. When the organism consists of a wholly soft and mobile material, as is the case with the amœbæ and many vegetable spores, its progression is a form of slow creeping by means of extemporized limbs, or pseudopodia, which are projected as wanted and withdrawn into the general mass after they have once been used. When the creature is of a firmer structure, with an

enveloping sack or skin, its movement is that of swimming, accomplished by the use of permanent hair-like filaments, called cilia, or whip-like lashes known as flagella, which act against the water and propel the creature with considerable velocity.

But the motion of the free diatoms is like neither the quick and nervous swimming, effected by cilia or flagella, nor the slow and measured crawling, performed by pseudopodia. It is in fact a somewhat jerky sort of glide. There are, nevertheless, advocates of the existence both of cilia and of pseudopodia as the means of the diatom's propulsion, although no certain glimpse has ever been obtained of either kind of organ.

In the genus *Navicula*, which includes most of the motile forms, a pretty good magnifying power discloses a central spot, or nodule, in the siliceous valve, with a line, or, in some cases, a double or bifurcate line, extending from it in either direction to the narrowed ends, as the frustule lies with its boat-like outline towards us. This median line is believed to be a lapped or rolled seam between two contiguous plates of which the valve is composed. Whether the edges are rolled so tightly as to form a closed joint, or the union is so loose as to leave an open slit, is still a debatable question ; but there seems to be no room for doubt that the thickened welt, to which the name *raphe* has been given, has with it a narrow groove of more or less depth. Now, the advocates of the pseudopod theory of locomotion commonly adhere to the belief in an actual cleft, through which the feet are supposed to be protruded from within the diatom; while the believers in the existence of cilia are generally disposed to accept either a closed or an open furrow as the seat of these oar-like appendages. Since the diatom is really a bivalve, you may begin to wonder why the workers over this problem have not located the organs of locomotion along the suture, or line of junction, between the two valves. But the objection to doing this is that the edges of the two valves are not actually in contact, but rather overlap, like the sections of a telescope tube, the diameter of one valve being slightly greater than that of the other. This overlapping is quite extensive in the larger forms, and gives rise to the appearance of a broad band or hoop encircling the frustule.

Unless, therefore, the raphe is accompanied by an open slit, the diatom is a tightly closed box with its living substance shut

up within. When binary subdivision takes place, the bottom and the top of the box slide apart, while a new top is built on to the old bottom and a new bottom on to the old top;—all inside of the telescopic tubes just mentioned, which are simultaneously extended and duplicated by depositions of new siliceous material upon the surface of the enclosed vegetating protoplasm. When the new frustules are completely formed they are set free by the slipping apart of the telescopic tubes, which, in the case of the free diatoms, usually fall away as genuine hoops, but in the case of the filamentous forms more generally remain adherent to the new frustules.

I have spoken of the living substance of the diatom as being sealed up within its glass case; but this view of the matter must be taken with some qualification, since the vital functions could not proceed unless there were communication of some kind between the endochrome and its environment. The silex-coated cell needs to be pervious to liquids and gases, as much as if it had only a cellulose wall, like most other plant-cells. From what we know of vegetable physiology generally, we do not run much risk in assuming that a constant interchange of elements takes place between the active body within and the world of inert matter without, by means of what is known as osmose.

This presumption has furnished the basis for a third theory of diatom-motion, which assumes that when endosmose occurs at one end of the frustule exosmose occurs at the other, and that the diatom is accordingly partly drawn and partly pushed along by this sucking and ejecting operation. It is held that the flow is not always in the same direction through the cell, but is subject to alternation, which some observers believe to be at regular intervals under all ordinary circumstances, though it is assumed to be more likely that the direction, duration, and change of the current depend upon some subtle and inconstant cause, like the action of light or of heat.

It is well known that all protoplasmic bodies are delicately sensitive to external stimuli, of which light is one of the most active and potent. The researches of Strasburger into "the action of light and of heat upon swarmspores" have shown that it is the actinic end of the spectrum which exerts the irritating influence which results in their migration, while the green, yellow

and red rays are inactive or neutral. Like the movement of swarmspores, as well as that of desmids, the locomotion of diatoms is influenced by light. If water containing these organisms is shaken up and poured out into a shallow vessel and set in a bright place, the diatoms will quickly separate themselves from the dirt and débris with which they have become mixed, and, rising to the surface, will gather together on the side of the vessel most under the influence of the light. The philosophy of this operation appears to be that the light promotes the chemical action, whatever it may be, within the protoplasmic contents of the frustule, which develops a force that reacts upon the water and results in the propulsion of the diatom in the direction of the light. I cannot myself understand why such a result should be produced if the cause of locomotion were the direct action of pseudopodia or cilia, unless we are to admit a certain degree of purposeful control of those organs towards the definite end of seeking the light,—which calls for an exercise of choice on the part of the diatom, at least equal to the apparent volition involved in the food-seeking movements of unquestioned animalcules. On some such theory as that of chemical or osmotic action promoted by light, however, I can easily imagine a reasonable explanation of the phenomenon not inconsistent with the generally accepted belief in the diatom's essentially vegetable nature.

By adopting this hypothesis, as I understand so high an authority as Prof. H. L. Smith has done, I confess that it seems to me we best get rid of that baffling question as to volition; for if the diatom's movements are merely a species of heliotropism, there is no more room for will or mind in the matter than there is in the case of any of the shrubs which turn their flowers or leaves in a given direction to the sun. Surely the evidence of choice in the action of the diatom is no greater than it is in the wonderful discrimination exercised by the roots, tendrils, and tentacles of higher plants, as shown by the delicate experiments of Charles Darwin and his son. I am aware, however, that it is laid down, as a fundamental axiom of psychology, that the function of selective discrimination is the root-principle of mind. But this train of thought leads to deeper questions than it is proper for me to enter upon at this time. I have endeavored, thus far, to confine myself mainly to those phases

of my subject which come naturally within the province of biology, or which present themselves to the mere observer with the microscope. While it is both easy and agreeable to wander in the paths of speculation, we must now keep to the direct line of tangible investigation, which leads us back to the consideration of our little silex-coated cell and its physical substance and structure.

From what has been said concerning the architecture of the typical frustule, you will have inferred that whenever, by any means, its organic material is destroyed, its two valves will fall apart, and that, if the diatom is in an advanced stage of incomplete subdivision, it will break up into four valves and two hoops. To such constituent parts the microscopist commonly reduces his diatomaceous material, by treatment with acids, for purposes of permanent mounting and preservation. Nature, also, is constantly removing the soft and perishable endochrome from diatoms which have run their life's course, and is steadily depositing their nearly indestructible remains at the bottom of almost every permanent body of water. As diatoms have swarmed in river, lake, and sea for countless ages, at least since the glacial epoch, their flinty shells have come to form beds and strata of very considerable extent in numerous parts of the world. Since the fresh-water, salt-water, and brackish-water deposits are very dissimilar in character, as are also the prevailing forms of different periods, these diatomaceous (or "infusorial") earths supply chapters in the history of our globe which are of very great interest and importance, but which some geologist will need to expound to you.

Amongst the largest and best-known of these deposits are that which underlies the city of Richmond, Virginia, and its vicinity, and the one near Virginia City, Nevada. The "Richmond earth" forms a stratum of from 8 to 30 feet in thickness, lying near the surface and extending throughout the eastern part of Virginia and portions of Maryland. There is some reason to suppose that this extensive deposit is related to if not actually connected with deposits recently discovered, at depths of several hundred feet, at Atlantic City and other points in Eastern New Jersey. The forms prevailing in these deposits are of the kinds peculiar to salt water, and their accumulation, in these immense beds of wide extent and great thickness, is evidence of a long-

continued submergence of the regions in which they are found beneath an arm of the sea.

The Nevada deposit is of very pure fresh-water forms, and was laid down in one of two great intra-glacial lakes, which geologists tell us were nearly as large as Lake Superior, one of which filled the Utah and the other the Nevada basin. The Nevada deposit has been worked commercially for a number of years, as the source of the polishing-powder which goes by the trade name of "Electro-Silicon." This and other diatomaceous earths are also employed to some extent, I believe, to form an absorbent base for certain high explosives. Indeed, very many of these earths are valuable articles of commerce, and I understand that at least one business house in this city makes a specialty of the trade in them. They furnish silica in a finely-divided form, suitable, amongst other things, for the manufacture of the silicate of soda or of potash, —otherwise known as "soluble glass,"—which is an ingredient in the glazing of pottery, in artificial stones, and in certain cements and paints.

But it is not because of their practical usefulness that diatomaceous earths are of interest to us. Our attention is now fixed upon diatoms merely as objects of scientific investigation and study.. Such they have been, in varying measure, in both their recent and their fossil forms, from almost the dawn of microscopical science, a little over two centuries ago,—observers having been attracted to them mainly by the beauty and variety of their shapes, of which you will presently be enabled to judge for yourselves, by means of the photographs which will be thrown upon the screen.

Under the microscopical powers of early days the valves of all but the very largest species appeared as simple in structure as if made of perfectly plain transparent glass. Some of the coarsest, particularly the discoidal forms, displayed upon their surface a dotting or embossing, with occasionally a rayed or more complicated pattern. A few of the angular forms presented a structure of coarse hexagonal netting, while some of the elongated and boat-shaped kinds were seen to be possessed of stout ribs running at right angles to the median line, or keel. At a later period, not only was the mere magnifying power of the microscope greatly increased, but, what proved to be of much more importance,

methods of illumination were devised which enabled the observer to throw beams of light of different sorts upon the object at various angles of incidence. By this means it was discovered that lined shadows were cast upon the surface of valves which had previously appeared entirely smooth and clear. It was found that these shadows are caused by shallow furrows running, not only lengthwise of the valve, but also at right angles to the median line or even obliquely to it. For a long time it was regarded as the acme of manipulative skill to display this simple system of striation upon the larger and coarser forms upon which the distance between the lines ranges from the 20,000th to the 50,000th of an inch. By slow degrees the microscopist attained to the ability to show at once two or more systems of lines, producing a cross-hatching with square, lozenge, or hexagonal interspaces, and at about the same time it began to be possible to discern upon some of the smaller specimens a striation having only the 80,000th or the 90,000th of an inch between lines. This was the maximum of attainment about thirty years ago. Since then progress has been slow in this department of microscopy and each small step achieved has caused a disproportionate amount of labor and discussion. But after a while an advance was made to the resolution of lines less than the 100,000th of an inch apart, upon such fine species as *Frustulia saxonica* and *Amphipleura pellucida*, and the methods which rendered this progress possible brought double systems of lines to view on those diatoms which had before shown only one system (like *Surrirella gemma*), and raised to the rank of well-defined dots the interspaces in the previous cross-hatching upon the more robust species, such as *Pleurosigma angulatum*. Then it was that microscopists ventured on the important generalization that the typical form of marking, throughout the whole subclass of diatomaceæ, is a series of dots, oftenest arranged in formal rows, but sometimes scattered irregularly over the shell.

As to the precise nature of these dots, there has always been, and is now, a wide difference of opinion, although I venture to think there is no scientific puzzle to the solution of which more intelligent effort has been devoted or over which a more earnest contention has prevailed. The combatants have arrayed themselves in three armies, defending respectively the theory of

bosses, of pittings, and of perforations. Until very recently the preponderance of opinion has been with the advocates of the existence of hemispherical protuberances from the outer surface of the valve. The valve itself has generally been taken to be a single layer of silex. But of late a good deal of evidence has accumulated to show that it is composed of at least two layers and perhaps three, and the idea is rapidly gaining ground that the dots are perforations of the middle layer, if there are three layers, or of the inner one, if there are only two. The outermost lamina and the innermost also, if the threefold theory holds, are supposed to be exceedingly thin, the main weight of material being in the perforated layer between. In fact, the outer layers are regarded as mere membranes overlying a sieve-like wall, of which the areolæ may be round, square, or hexagonal in form.

This last-named theory accords best of all with our belief in the vegetable nature of the diatoms and what we know to be the requirements of the vegetable cell. The sum and substance of this theory is that the cell-wall is not a solid and impervious mass of silex, as was formerly supposed, but that the arrangement of layers which I have described gives it a semi-punctate structure which, while affording all necessary strength, allows full play to the vegetative processes which, through osmotic action or otherwise, depend upon communication between the enclosed endochrome and the exterior world.

But all this brings us once more face to face with the biological problems with which we began the consideration of this subject this evening. As I predicted at the beginning of this lecture, our latest and most extended knowledge, like our earliest and simplest, ends at the everlasting interrogation-mark. There never can be a finality to human research. Physicists speak with some confidence of an ultimate indivisible unit, the size of which they even undertake to estimate in a rough sort of way; and yet if, in the course of ages to come, the power of the microscope should actually reach that degree of development which was falsely claimed for it a century and a half ago (when Joseph Highmore and others declared that the lenses of that day enabled one to see "the atoms of Epicurus" and "the subtile matter of Des Cartes"), I have no idea that there would be a cessation of microscopical endeavor, or that there would be any

general concurrence in the belief that the final unit of all material things had been reached. You may be sure there would still be a goodly number of men endowed with that high order of inquisitiveness which finds its full satisfaction in merely solving problems, and who would persist in peering and prying, determined to find something beyond the so-called end.

Of this class are the men who have worked away at the diatom-markings, through good report and evil report, encouraged and sustained by an abiding faith in the intrinsic value of pure truth. To one unfamiliar with microscopical science the length of time and amount of labor, on the part of both the worker with and the constructor of lenses, which were required to accomplish the progress in mere technical achievement which I have briefly described, must be a matter of profound surprise and wonder; and even after one has in a measure realized that many years of patient and persistent effort were consumed in getting over the ground between merely seeing plain lines the 50,000th of an inch apart, and breaking those lines up into visible dots having a distance of the 50,000th of an inch between their centres (which is in most cases the equivalent of resolving lines the 100,000th of an inch apart), he may still be unable to appreciate the importance of the accomplishment or to believe that the result could warrant the necessary expenditure of energy. But the pursuit of knowledge for the sole sake of knowledge has been justified over and over again by the discovery that what was sought with entirely disinterested motive and with no utilitarian aim, has proved to be a precious boon and blessing to all mankind. And so the enthusiasts who used to spend their time "fighting objectives," and who braved the jeers of their more practical brethren, have now the satisfaction of knowing that their exacting demands for improved apparatus with which to resolve more and more difficult tests, have been the incentive under which the opticians have produced lenses of wider and wider angle of aperture, with better and better correction of aberrations. The result has been, first, the working out of the very ingenious homogeneous immersion principle and, more lately, of the wonderfully delicate apochromatic combination, in the application of which to the microscope objective a revolutionary theory in optics has been developed, while, at the same

time, the whole science of bacteriology has been rendered practicable, and the mysteries of disease and death have been disclosed to seers like Pasteur and Koch, for the benefit of us and all coming generations.

ON THE EFFECTS OF HYDROXYLAMINE AS A PARALYZING AGENT FOR CONTRACTILE ELEMENTS.[1]

BY E. A. SCHULTZE.

(*Read November 20th*, 1891.)

The preparation for microscopical study of animals having exceedingly contractile elements, and which when killed are, in consequence of the irritating properties of the embedding material, often rendered unrecognizable, may be added to the more difficult methods employed in the art of preservation.

Thus, for instance, in preparing slides of infusoria great difficulties are met in fixing Stentor, Vorticella, Spirostoma, etc., and it is always a matter of chance if one or the other of these animals is secured in a partially extended state by the methods in use up to the present time. Similar difficulties are encountered in fixing Hydrozoa, and especially Actinozoa, Planariæ, Rotifera, and all kinds of mollusca, etc., all of which shrink more or less under the influence of the preservative reagents.

In order to overcome as far as possible these difficulties which occur in course of scientific investigation, and especially in slides prepared for school use, two methods have been adopted which in some few cases have proved successful.

At first the attempt was made to instantly kill metabolic animals in a distended state by means of extremely effective agents, such as Lang's solution, which may be successfully used on Planariæ, osmic acid for many Protozoa, corrosive sublimate, and other boiling reagents. But as the effects produced by these methods, despite their excellent preserving qualities, are generally restricted, the trial was made to paralyze the contractile elements by means

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[1] Abstract and translation from an article by Dr. Bruno Hofer in Zeitschrift für wissenschaftliche Mikroskopie, vii. 318 (1890).

of proper poisons, and then to fix the paralyzed animal. Satisfactory results were thus obtained by the use of chloral and different alkaloids, such as cocaine, antipyrine, antifebrine, etc., with or without subsequent poisoning. These paralyzing methods, which, moreover, are not always effective, have the great disadvantage that, through the action of the paralyzing reagents, which are in most cases specific protoplasmic poisons, a simultaneous swelling of the protoplasm occurs, so that, although the topographical conditions are retained, the histological details are in many cases destroyed.

On that account a method is to be desired which will permit metabolic animal forms to be fixed in a distended state, and at the same time sufficiently insure their preservation, especially in the case of those animals which have hitherto resisted all attempts towards preservation. These results are to be obtained, as I have subsequently shown in a series of experiments, with the aid of hydroxylamine, *i.e.*, with its hydrochlorate or sulphate, by means of which the smooth and striated muscles of many Metazoa are paralyzed to such an extent that a subsequent contraction, while fixing them afterward, is hardly perceptible. A sufficient paralysis is also obtained before a swelling of the protoplasm in the cells of the paralyzed object is noticeable.

A series of careful examinations with abundant material will have to be made to determine to what extent hydroxylamine poisoning may be used. The favorable results that I have obtained with Protozoa, Hydrozoa, Actinozoa, Planariæ, Annelida, Rotifera, Mollusca, etc., lead me to believe that hydroxylamine, as a paralyzing agent, will be more generally used.

The following directions may be recommended in using hydroxylamine:

One per cent of the crystals of the commercial hydrochlorate, which are usually impure, is dissolved in fresh water, and enough carbonate of soda added to render the solution neutral. This solution may be kept on hand in large quantities for use at any time. Distilled water must not be used in preparing it, but in the case of marine forms salt water must necessarily take the place of fresh. It is not advisable to eliminate the hydroxylamine from the hydrochlorate solution by adding an excess of carbonate of soda, as the liquid then obtained would over-excite the animal.

After the animals have been paralyzed in the neutral hydrochlorate solution they are immediately covered with the fixing medium and thereby killed.

The number of fixing reagents that may be used is of course limited. For, hydroxylamine being a powerful reducing medium, all easily reducible agents, such as osmic acid, corrosive sublimate, chloride of gold, of platinum, etc., cannot be directly applied. The hydroxylamine must first be worked out with water. Alcohol, acetic and picric acids, and mixtures of these two acids may be directly applied, and with these a good histological slide may always be obtained.

The strength of the solution depends, of course, on the nature of the animal to be mounted. In the case of a few special objects I find the following directions may be respectively used :

1. *Stentor cœruleus.*—Place the Stentors for ten or fifteen minutes in a 0.25-per-cent solution of the hydrochlorate. A large proportion of the animals soon stretch themselves out and remain in the semi-distended condition which free-swimming Stentors usually show. No subsequent contraction occurs. The paralyzing effect of the hydroxylamine is soon apparent, but is, however, not sufficiently complete to commence the fixing process. The paralysis must first extend to the cilia. After some ten minutes the cilia of the peristome move irregularly and slower, and finally cease moving altogether. This change must be carefully noted, for at this step the Stentors are suddenly flooded with a concentrated solution of picric acid mixed with a 5-per-cent solution of acetic acid. The majority of the Stentors are now pear-shaped; a few are distended their full length ; while others have the same round shape that Stentors assume when fixed before having been previously paralyzed. The peristome cilia of each individual remain extended and are not drawn back. Sometimes the smaller forms are killed inside of ten minutes through the action of the hydroxylamine, the protoplasm swells, and the animals are entirely deformed. It is consequently always necessary to observe the action of the hydroxylamine from time to time through the microscope, and to add the picric acid before the protoplasm in the larger forms appears to swell; for if left too long the hydroxylamine will act as a poison on the protoplasm, as has been shown by Loew in his experiments with vegetable protoplasm. If the action be stopped, how-

ever, at the right moment, the histological details will be preserved. The Stentors may then be washed in alcohol of 70 per cent, and stained in a rose-red solution of borax-carmine in hydrochloric alcohol of 70 per cent. A satisfactory stain will be obtained in about one hour's time. The Stentors being likely to contract if transferred from absolute alcohol directly to oil of cloves, it is advisable to place them in oil of cloves strongly diluted with absolute alcohol, which latter is allowed to evaporate. This proceeding must be followed when mounting the specimens in Canada balsam. If all the above-mentioned details are adhered to, better slides will be obtained than have been produced by any other method.

2. *Spirostomum teres.*—These extraordinarily sensitive infusorians may be treated in the same manner.

3. *Carchesium polypinum.*—The difficulty in preparing *Carchesium* and many other Vorticellidæ lies in the fact that the muscles of the peduncles strongly contract when brought in contact with the preserving liquid, in consequence of which the individuals of a colony are drawn together and the natural bell-shaped form becomes rounded. To overcome this place the *Carchesia* in a 0.2-per-cent solution of hydrochloric hydroxylamine. The peduncles cease their periodic contractions after one or two minutes, and remain distended. After about five minutes the cilia move more slowly, and ten minutes later the individuals are ready to be killed, like the Stentors, by means of picric-acetic acid.

4. *Hydra grisea.*—Although this object is a comparatively easy one to prepare with any good paralyzing agent, I wished to try the hydroxylamine-poisoning process, in order to study the effects it would have on all the different muscles. Besides, the effects on *Hydra* of a 0.25-per-cent solution of hydroxylamine chloride are such that not only the body proper remains distended, but the mouth also sometimes remains open.

5. *Dendrocœlum lacteum.*—In spite of the fact that very good results in preparing sections of Planaria may be obtained with the use of Lang's solution, the latter is unfit for mounting whole specimens, because the usually thick and massive animals, which must be pressed for this purpose, cannot become flattened after they have become hard. It is therefore necessary to place the live animal under the cover glass, press it slightly, and then flow in

the preserving liquid. But, on account of the irritation to which the animal is subjected by this method, abnormal contractions usually occur. It is consequently advisable to first paralyze the muscular system with hydroxylamine, then to flatten the animal under the cover glass, and finally kill it with picric-acetic acid. For paralyzing *Dendrocœlum lacteum* ten or fifteen minutes are sufficient, with a 0.5-per-cent solution of hydroxylamine chloride. The moment the animal stops moving is the best time to kill it.

6. *Hirudo medicinalis*.—To produce good sections of leeches the body must show no contraction after being killed. Chloroform as a paralyzing agent cannot be recommended, as, on account of excessive irritation, the muscles of the leech are often torn. When placed in a 1-per-cent solution of hydroxylamine chloride, the animals stretch themselves out to their full normal length after from one-half to two hours' time, and remain in this state after the fixing medium is added, which may be either alcohol or picric-acetic acid.

7. *Naïs proboscidea*.—*Naïs* has a tendency, when placed in the preserving fluid, to roll itself up sideways and perceptibly shorten its segments. A side view of the body is of course advantageous or the study of the nervous system, but the segmental organs are not visible in this position, as they are covered by the intestines. In order to properly see them the animal must be fixed on its belly or back, when the entire segmental structure is shown. Place the *Naïs* in a 0.1-per-cent solution of hydroxylamine chloride. After twenty or thirty minutes the skin muscles are so lame that the animal hardly moves, and may be fixed on the slide in any position with picric-acetic acid. The specific muscle-paralyzing action of hydroxylamine is especially noticeable in *Naïs proboscidea*, for the animal may remain one hour and a half in the hydroxylamine solution without the ciliary motion in the rectum entirely ceasing, while the skin muscles have become incapable of contraction after about half an hour. Moreover, *Naïs* is able to recover its natural condition if transferred to pure water. The ciliary motion of the rectum again becomes active, and later the skin muscles regain their contractile ability. It is consequently possible, after thoroughly washing the paralyzed animal for about ten minutes, to kill it with other reagents than picric-acetic acid—

for instance with osmic acid, a proceeding to be recommended for studying the segmental canal.

8. *Rotifera.*—The action of hydroxylamine on Rotifers, of which *Noteus quadricornis*, *Squamella bractea*, and *Salpina spinigera* were examined, is also advantageous. After applying a 0.1-per-cent solution the cilia of the discs, as well as the muscles of the tail-like foot, become so lame that both wheel-organ and foot are not drawn in when being fixed with picric-acetic acid.

9. *Mollusca.*—For *Anodonta cygnea* and *Helix pomatia* I recommend a $\frac{1}{2}$ to 1 per cent solution. Both specimens were entirely paralyzed after from ten to twenty hours. The snail had stretched itself out of its house as it usually does while moving in life. The mussel had extended its foot, and the closing muscles of the shell were completely paralyzed. While afterwards fixing in alcohol the animals remained unchanged.

The aforementioned examples are illustrations of the fact that hydroxylamine possesses a paralyzing power in contractile elements, and that it may be used very successfully in mounting.

PROCEEDINGS.

Meeting of October 2d, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Twenty-five persons present.

Dr. Charles Lehlbach was elected a resident member.

The Recording Secretary read a communication from the Scientific Alliance of New York requesting the Society to unite in arranging a mutual programme.

On motion it was resolved that the matter be referred to the Board of Managers to report at the next meeting.

The Corresponding Secretary announced a donation of diatomaceous material from Mr. K. M. Cunningham, of Mobile, Alabama, accompanied by the following communication dated August 11th, 1891:

"To-day I mailed to your address a specimen of a new diatomaceous material find, recently brought to light by myself. This material is sufficiently cleaned to mount directly. It is from the west bank of the Mobile River, and is a tidal marsh mud taken from three to five feet below the surface, and has probably not been seen heretofore by diatom admirers. Four or five forms occur in great abundance—*Campylodiscus*, *Actinocyclus*, *Terpsinoe*, with a sprinkling of others.

"The material will make elegant balsam or dry mounts for condensed surface illumination for binocular. It is a cleaning by Dr. Geo. H. Taylor, of Mobile, and is of unusual interest before acid treatment, as it shows a fair mixture of a wide variety of rhizopods, sponge spicules and diatoms, not to mention a great variety of transparent plant tissues of great diversity of cellular structure, with scales of mica, which polarize very prettily."

Mr. Hyatt announced the finding of marine forms of diatoms in the filter beds of the city water works of Poughkeepsie, New York.

Dr. E. G. Love addressed the Society on "The History and Development of the Microscope up to the time of Achromatism." This address was a most interesting and able explication of the subject, and was beautifully illustrated by the projection of fifty lantern slides of diagrams, antique instruments and accessories.

Meeting of October 16th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Twenty-eight persons present.

The Corresponding Secretary announced the donation to the Society of seventy-five slides of diatoms by Mr. Henry C. Bennett, prepared by him and accompanied by the following communication :

"I prepared the slides from cleaned material obtained from abroad, and they comprise deposits from districts that have received much attention from diatomists, and which have been described in scientific publications. The cleaned diatomaceous material I obtained from M. J. Tempère, 168 Rue St. Antoine, Paris, France, who at intervals of about three months issues a series of twelve tubes of cleaned diatoms in liquid, each tube holding about one-half of a drachm."

OBJECTS EXHIBITED.

1–4. Four new forms of aquatic animal life from the Morris and Essex Canal, N. J.: by STEPHEN HELM.

5. *Bacillaria paradoxa*, living, from the Morris and Essex Canal: by JAMES WALKER.

6. The Worker Ant, *Myrmica scabrinodis* Nyl.: by J. L. ZABRISKIE.

7. Sting of Wasp, with air in the longitudinal canal of one lance, showing branches of the canal to the barbs: by J. D. MALLONEE.

Meeting of November 6th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Thirty-three persons present.

Dr. J. A. Gottlieb was elected a resident member.

The following persons were appointed by the chair Committee on Annual Reception: Anthony Woodward, Dr. Edward G. Love, and Charles S. Shultz.

OBJECTS EXHIBITED.

1. *Cordylophora lacustris:* by H. CALEF.

2. Transverse sections of Antennæ of House-fly, *Musca*

domestica, showing grooves, horny discs, and fine hairs: by L. RIEDERER.

3. Sagittal sections of head of Stable-fly, *Stomoxys calcitrans*: by L. RIEDERER.

4. *Trichina spiralis* in human muscle: by J. A. GOTTLIEB.

5. One of the new forms of aquatic life exhibited at the last meeting: by STEPHEN HELM.

6. Section of leaf of Oleander showing stomata: by F. W. LEGGETT.

7. Section of leaf of Rubber Plant showing stomata: by F. W. LEGGETT.

8. Portion of stem of Sleepy Catch-fly, *Silene antirrhina* L., with captive insect: by J. L. ZABRISKIE.

9. Leaf-blade of Long-leaved Sun-dew, *Drosera longifolia* L., with captive insect: by J. L. ZABRISKIE.

Dr. Gottlieb gave a very interesting account of the nature and action of *Trichina*, and stated concerning the exhibit that it was taken from the biceps muscle at the autopsy of an Italian who entered Bellevue Hospital under the Doctor's care in the spring of 1890, and who died three weeks after, suffering from trichinosis.

Mr. Riederer explained his exhibits, using in illustration excellent colored drawings of his own preparation.

Mr. Zabriskie exhibited in connection with his slides herbarium specimens of *Silene antirrhina* L., *Drosera rotundifolia* L., *D. longifolia* L., and *D. filiformis* Raf.

Mr. Hyatt stated that the glandular hairs of the leaf of *Drosera* will not move on contact with inorganic matter, but that they will contract upon a minute piece of fresh meat in the space of twenty seconds; and further, that in his experience the insects most abundantly captured by *Drosera* are ants.

Dr. N. L. Britton gave an interesting description of a large insectivorous plant, of the genus *Roridula*, living specimens of which he had seen at the Royal Gardens at Edinburgh. The plant is a native of Tasmania. It is a branching bush, with filiform leaves, more slender than those of *Drosera*, and, like the latter, furnished with glandular hairs with which it captures flies.

Meeting of November 20th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Forty persons present.

Mr. M. A. Gottlieb was elected a resident member.

The Vice-President reported the decision of the Board of Managers, that it is desirable that the programme of the Society be published in the Bulletin of the Scientific Alliance.

On motion it was resolved that the report be adopted, and that the necessary expense be met from the funds of the Society.

On motion it was resolved that the Society hold an Annual Reception.

The chair appointed the following as Committee on Nomination of Officers: Walter H. Mead, William G. De Witt, and F. W. Devoe.

The Corresponding Secretary announced the donation to the Society, by Mr. K. M. Cunningham, of Mobile, Alabama, of our prepared slides of rhizopods and two vials of material, accompanied by the following communication dated November 14th, 1891:

"The preparations are the outcome of my most recent find of a diatom-bearing material on the eastern edge of a marsh bordering the Mobile River. The vegetable growth, mostly marsh grasses, rests upon a stratum of a very soft, oozy mud, through which a pole may be readily pushed for a depth of six feet. When withdrawn, the soft mud is scraped off and subjected to the usual treatment for the removal and concentration of diatoms.

"This mud proved to be of unusual richness in variety of micro-organic remains, as may be attested by an examination of the slides prepared from the same. Associated together may be found marine and fresh-water species of diatoms, several interesting varieties of sponge spicules, very numerous tests or carapaces of fresh-water rhizopods, and several species of marine foraminifera. Also there may be seen varieties of pollen grains or spore capsules, many plates of mica, and of less interest the tissues of plants of a partially siliceous nature—*Phytolitharia* (Ehrenberg).

"I have prepared, in a probably unusual manner, a set of four

slides to illustrate some of the features connected with this special deposit. On two slides I show selected rhizopods, to be viewed strictly by polarized light; and two slides of deposit strewn so as to show the various associated micro-organisms by polarized light. These slides have no cover glasses, but are covered by a thin film of mica, with the object of intensifying the brilliancy of the prismatic effects. Under this arrangement we are provided with a kaleidoscopic effect of color, produced by the polarized light when the polarizing prism is revolved.

"I have also sent two vials, one containing the rhizopod, foraminifera, and mica material, the other containing the marine and fresh-water diatoms, concentrated from the mud already alluded to. The diatoms are a water-washed concentration by Dr. Geo. H. Taylor, of Mobile, without use of acids. He is now engaged on the reduction of a large bucketful of the deposit to the same state as that shown by the slide of diatoms prepared from the material in the vial sent herewith. The diatoms indicate an aggregation of about fifty marine and fresh-water species—*Actinocyclus Ehrenbergii*, *Campylodiscus crebrosus*, *Nitzschia circumsuta*, and *Terpsinoe musica*. Another interesting feature is that *Triceratium favus* is absolutely absent, and that *Cymatopleura elliptica* and a pretty *Acanthes* are seen in every slide of the material, while they are almost unknown as occurring in all previous gatherings tributary to Mobile until this locality was casually met."

OBJECTS EXHIBITED.

1. Vanadamite from Arizona: by E. C. Bolles.

2. Percylite from Arizona, together with a large series of minerals in minute paper boxes: by E. C. Bolles.

3. Rhizopods from marsh mud, Mobile River, Alabama, prepared and donated by K. M. Cunningham: by J. L. Zabriskie.

4. A slug-like form of aquatic life: by Stephen Helm.

5. An undescribed form of aquatic life, formerly exhibited as No. 4: by Stephen Helm.

6. An undescribed form of aquatic life resembling *Cordylophora lacustris:* by Stephen Helm.

7. *Hydra viridis:* by Stephen Helm.

8. Young Hydro-medusæ, living: by L. Riederer.

9. Poison from stems of grapes: by L. RIEDERER.

10. Transverse section of leaf of Oleander with stomata: by E. G. LOVE.

11. Section of agate: by J. D. HYATT.

Mr. E. A. Schultze read a translation from *Zeitschrift für wissenschaftliche Mikroskopie*, entitled "On the Effects of Hydroxylamine as a Paralyzing Agent for Contractile Elements." This translation is published in full in this number of the JOURNAL, p. 28.

Rev. Dr. Bolles explained at length the advantages of the minute square paper boxes containing the mineralogical specimens exhibited by him. A short section of a small cylinder of wood is glued in the bottom of each box; a disc of black cardboard is glued on top of the wood, and the specimen is attached to the black disc.

This was followed by a discussion on the sweating of cells containing dry mounts, and especially on the disadvantages of wax cells, which discussion was participated in by Messrs. Cox, Bolles, Hyatt, Leggett, and Zabriskie.

Dr. E. G. Love stated concerning his exhibit that the peculiar appearance of the stomata of the Oleander was due to the fact that the stomata are each seated at the bottom of a little depression in the surface of the leaf, the depressions being lined with minute hairs. Dr. Carpenter mentions this in his work on the microscope, and it probably occurs in only a few genera of plants.

Mr. Hyatt said of his beautiful section of agate that it was composed of aggregated clusters of minute crystals of quartz, showing hexagonal structure of the crystals.

PUBLICATIONS RECEIVED.

The Microscope: Vol. XI., Nos. 8—11 (August—November, 1891).

American Monthly Microscopical Journal: Vol. XII., Nos. 10, 11 (October, November, 1891).

Anthony's Photographic Bulletin: Vol. XXII., Nos. 19—23 (October 10—December 12, 1891).

Botanical Gazette: Vol. XVI., Nos. 11, 12 (November, December, 1891).

Bulletin of the Torrey Botanical Club: Vol. XVIII., Nos. 10—12 (October—December, 1891).

Insect Life: Vol. IV., Nos. 1—4 (October, November, 1891).

Psyche: Vol. VI., Nos. 187, 188 (November, December, 1891).

West American Scientist: Vol. VII., No. 63 (October, 1891).

Natural Science Association of Staten Island, Proceedings: Meetings of October 10, November 14, 1891.

San Francisco Microscopical Society, Proceedings: Meetings of October 7—November 18, 1891.

Journal of the Elisha Mitchell Scientific Society: Part 1, 1891.

Journal of the New Jersey Natural History Society: Vol. II., No. 2 (January, 1891).

Kansas City Scientist: Vol. V., No. 10 (October, 1891).

Bulletin of Michigan Agricultural Experiment Station: Nos. 75—77 (July—November, 1891).

Bulletin of Cornell University Agricultural Experiment Station: No. 32 (October, 1891).

The Microscope and Histology, Part 1: From the author, Dr. S. H. Gage (1891).

The Eleventh Census, An Address: From the author, Hon. Robert P. Porter (October, 1891).

Journal of the Royal Microscopical Society: Part 5, 1891.

International Journal of Microscopy and Natural Science: Vol. I., Nos. 10—12 (October—December, 1891).

Grevillea: No. 94 (December, 1891).

The Naturalist: Nos. 195, 196 (October, November, 1891).

Transactions of the Canadian Institute: Vol. II., Part 1 (October, 1891).

The Ottawa Naturalist: Vol. V., Nos. 6, 7 (October, November, 1891).

The Victorian Naturalist: Vol. VIII., Nos. 5, 6 (September, October, 1891).

Brooklyn Medical Journal: Vol. V., Nos. 11, 12 (November, December, 1891).

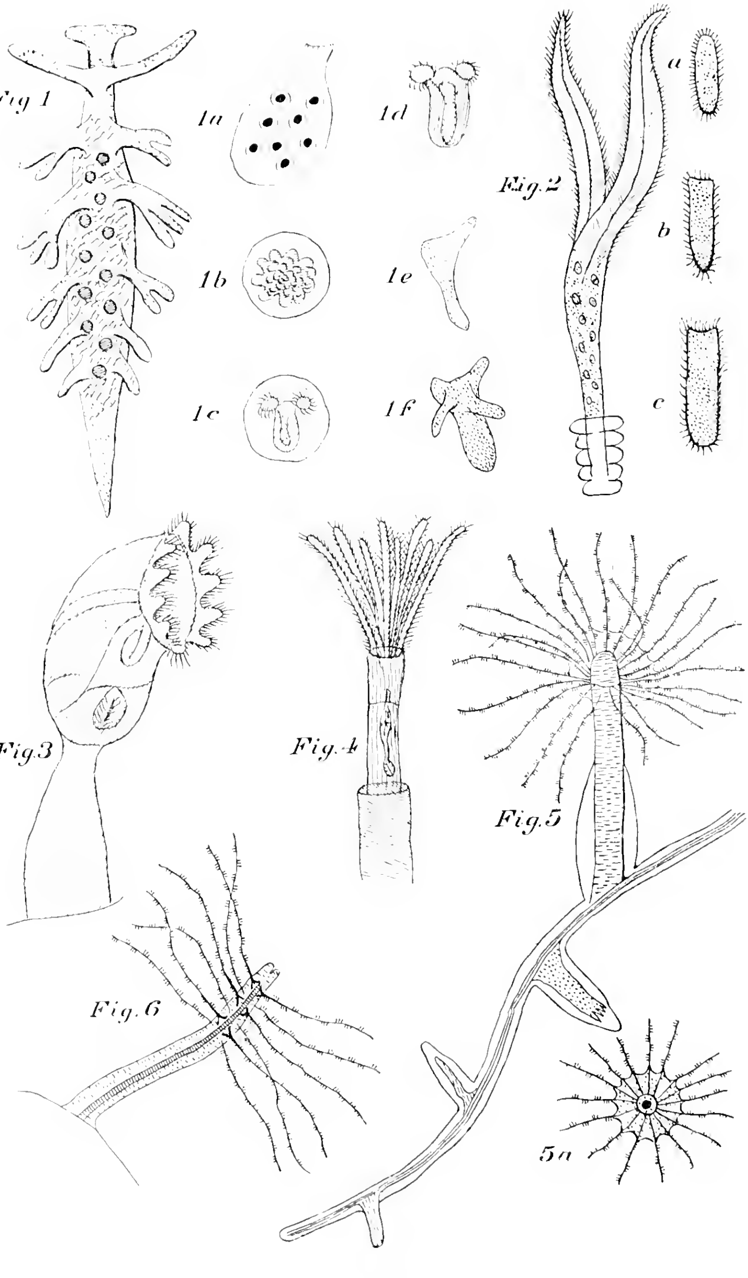
Indiana Medical Journal: Vol. X., Nos. 4—6 (October—December, 1891).

Hahnemannian Monthly: Vol. XXVI., Nos. 10—12 (October—December, 1891).

The Satellite: Vol. V., Nos. 2, 3 (October, November, 1891).

Electrical Engineer: Vol. XII., Nos. 179—189 (October 7—December 16, 1891).

American Lancet: Vol. XV., Nos. 11, 12 (November, December, 1891).



HELM ON AQUATIC LIFE.

National Druggist: Vol. XIX., Nos. 8—12 (October 15—December 15, 1891).

Johns Hopkins University Circulars: Vol. XI., Nos. 92—94 (November, December, 1891).

Mining and Scientific Review: Vol. XXVII., Nos. 14—23 (October 8—December 10, 1891).

Bulletin de la Société Belge de Microscopie: Vol. XVII., No. 10 (October, 1891).

Bulletin de la Société Royale de Botanique de Belgique: Vol. XXX., Part 1 (1891). Comptes-Rendus (July 19, 1891).

Wissenschaftlicher Club in Wien: Monatsblätter, Vol. XII., No. 12—Vol. XIII., No. 2 (September—November, 1891). Ausserordentliche Beilage, Vol. XII., No. 12, Vol. XIII., No. 1 (September, November, 1891).

Nuovo Giornale Botanico Italiano: Vol. XXIII., No. 4 (October, 1891).

La Notarisia: Vol. VI., No. 26 (August, 1891).

Jahrbücher des Nassauischen Vereins für Naturkunde: Vol. XLIV. (1891).

Verein für Naturkunde zu Kassel, Bericht: Vol. XXXVI., XXXVII. (1889, 1890).

Jahresbericht der Naturhistorischen Gesellschaft zu Nürnberg (1889).

Naturwissenschaftlicher Verein, Frankfurt (Oder), Helios: Vol. IX., Nos. 4—6 (July—September, 1891). Societatum Litteræ: Vol. V., Nos. 5—8 (May—August, 1891).

Revisio Generum Plantarum, Part I. By Dr. Otto Kuntze. From the author (1891).

Sociedad Cientifica "Antonio Alzate." Memorias: Vol. IV., Nos. 11, 12 (May, June, 1891).

Revue International de Bibliographie Médicale, Beyrouth: Vol. II., Nos. 9—11 (September—November, 1891).

American Metrological Society, Metrical Tables (1891).

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CORDYLOPHORA LACUSTRIS, AND FIVE NEW FORMS OF ANIMAL LIFE.

BY STEPHEN HELM.

(*Read December 4th*, 1891.)

In the latter part of September last I explored the portion of the Morris & Essex Canal lying between Pamrapo and Newark Bay, N. J. On first inspection the result was disappointing, but a more careful examination revealed isolated specimens of two forms (Pl. 29, Figs. 3 and 4) which were new to me. Thinking it probable that another part of the same canal might perhaps yield better results, I, on another occasion, proceeded to that section lying between Greenville and Claremont.

Here, to my intense satisfaction, I found the same two forms in considerable abundance, and, to my delight, three others which were also new to me (Pl. 29, Figs. 1, 2, 5). The question then arose, What are they? After carefully searching through all the literature on the subject at my command, after communication

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Explanation of Plate 29.

FIG. 1. The molluscan designated as No. 1. 1*a*. Egg-cluster as first observed. 1*b*. Egg, with mulberry-shaped contents. 1*c*. The same advanced to a rotifer-like form. 1*d*. The free swimming "rotifer." 1*e*. The same at time of attachment. 1*f*. The same with budding processes.—FIG. 2. *Lagotia cæruleus* Helm. 2 *a*, *b*, *c*. Stages of development (after Wright).—FIG. 3. *Urnatella Walkerii* Helm.—FIG. 4. *Octocella libertas* Helm.—FIG. 5. *Cordylophora coronata* Helm. 5*a*. The same: view of tentacles, web, and oral aperture from above.—FIG. 6. *Cordylophora lacustris* Allman.

with many microscopists of large experience, and after considerable correspondence, I fail to find any record of these specific forms. I am, therefore, driven to the conclusion that they are new to this country, and probably new to science, and the pleasurable duty of introducing them devolves on me.

Should the publication of this paper, however, lead to their identification, I shall be glad to receive any communication on the subject, and shall even then have the satisfaction of rescuing from partial oblivion forms which ought not to remain in obscurity.

One of the gentlemen whose counsel I sought was Dr. A. C. Stokes, of Trenton, N. J., editor of *The Microscope*, and a corresponding member of this Society. He very courteously replied that all except No. 5 were new to him, and that he thought, from my drawing, was *Cordylophora lacustris;* and if not, then it was an allied species.

I have since had considerable correspondence with him, and, although personally a stranger, he has evinced intense interest in my finds; and whilst he is a very busy man, I hope to have the advantage of his critical experience in the preparation of the more technical descriptions of these forms, which I propose to prepare during the remaining winter months.

As to the names which I have attached to four of the five forms, I wish explicitly to state that they are provisional only, and are given pending the settlement of the question whether they are new or only rare species.

The remaining form, though unquestionably a molluscan, differs so widely from hitherto described forms that it seems to demand a niche for itself. I therefore await results, and shall, whilst endeavoring to complete my observations, in the meantime designate it as No. 1.

On my first introduction to it, all I saw were two processes, standing out from confervoid and other growth, on the stem of a plant I was examining for other objects. A current was being produced as powerful as that of *Melicerta* and other large Rotifera, and presently more processes, and finally an entire animal crept into the field of view—an animal so unlike anything I had seen before, or even remembered to have read of, that I was at first amazed and then intensely interested. For its size

Fig. 2.

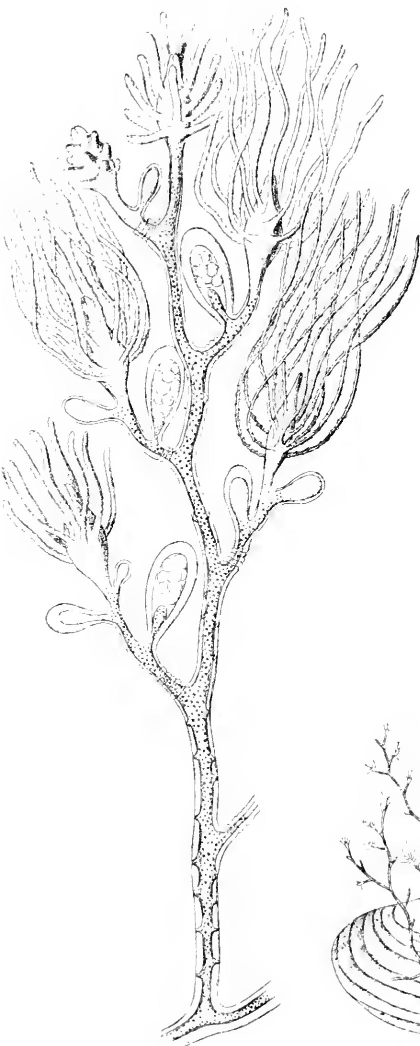


Fig. 3

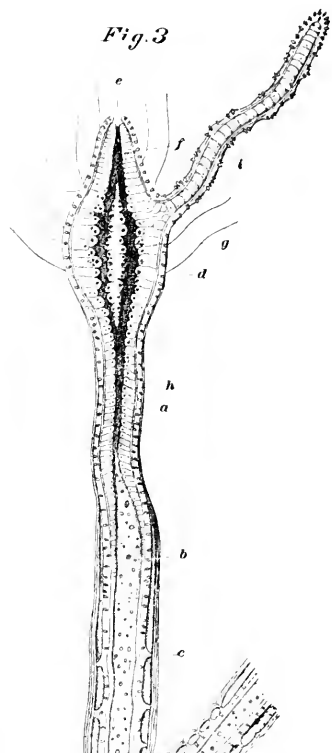
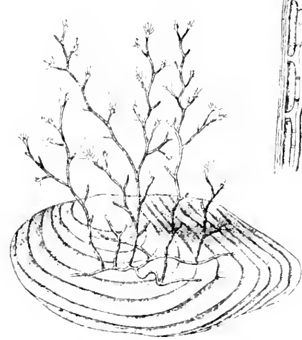


Fig. 1



CORDYLOPHORA LACUSTRIS.

—one-fourth of an inch in length—and means of locomotion, it moves pretty rapidly and without any apparent effort, its motion being the easy, firm, sliding movement so familiar in the slug and snail.

The processes seem to develop with the growth of the animal, the maximum number I have seen being seven pairs. The two anterior processes are more pointed than any of the others, and are generally directed forward. Of the remainder, the second pair is forked for about one-half of the long diameter; the third pair divided into three; the fourth into two again; whilst the remainder are single, the posterior pair being considerably smaller than the others. They are all slightly inclined backward as the animal moves along. The body terminates in a pointed tail equal to about one-third of its length.

The current is produced by innumerable "papillæ," which move with a sort of undulatory motion and apparently cover every portion of the body. The first impression produced is that of cilia, and in certain lights it is difficult to persuade one's self they are not, as when seen edgewise they are very thin. They are often quiescent, and what purpose their motion serves I cannot imagine, as the animal seems to feed slug-fashion; and though I have not yet made out its mouth, its possession of a lingual membrane presupposes the existence of one.

I have not absolutely satisfied myself as to the method of reproduction, but after many observations have arrived at certain conclusions. The body is composed of sarcode, and in the tail a rapid circulation may be seen; but the central portion of the body is so opaque that very little can be made out without dissection, and until my stock increases I am loath to sacrifice many in that way. Underneath the frog-like pigment cells of the back I have observed many round cells, and, suspecting them to be immature egg clusters, I isolated two specimens and found my suspicions

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Explanation of Plate 30. (After Allman.)

FIG. 1. *Cordylophora lacustris* Allman, attached to a dead valve of *Anodon cygneus*. Reduced two-thirds natural size.—FIG. 2. A branch, magnified, with the polyps in various states of expansion, and with the reproductive capsules more or less developed.—FIG. 3. Longitudinal section of polyp, to show the details of its structure. *a*. Ectoderm. *b*. Polypary. *c*. Processes from the ectoderm attached to inner surface of the polypary. *d*. Endoderm. *e*. Mouth. *f*. Post-buccal cavity. *g*. Stomach. *h*. Common canal of the cœnosarc. *i*. Muscles.

confirmed by the deposition within three or four days of several clusters, containing from four to eighteen eggs each (Fig. 1*a*). These I carefully watched, and after some days observed :

1. The dense contents gradually assumed a mulberry shape (Fig. 1*b*), and then there set in a rapid revolution of the cell contents.

2. A development of a rotifer-like form (Fig. 1*c*) with two strongly ciliated heads, always in motion, but still within the egg.

3. The rotifer-like form escaped (Fig. 1*d*) and became a free swimmer. It now had a kind of tail in process of development.

4. The ciliated heads disappeared, and attached by the tail it assumed the form shown in Fig. 1*e*.

Unfortunately, I am not able to devote continuous observation to my specimens, hence my uncertainty ; but I have further seen what I believe to be developed from Fig. 1*e*—a form (Fig. 1*f*) with one pair of processes, and another with three pairs, my first specimen having six pairs.

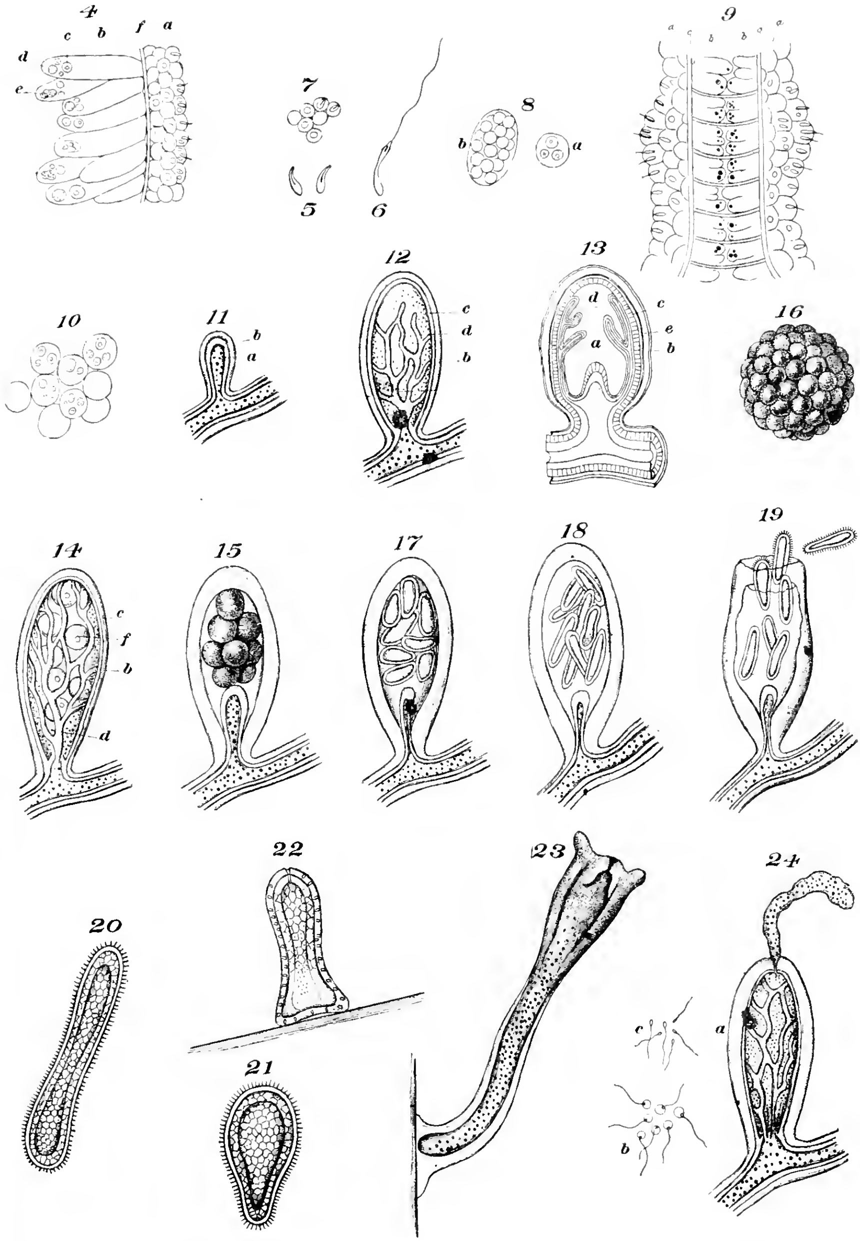
LAGOTIA CÆRULEUS sp. n. (Pl. 29, Fig. 2).

Figure 2 must undoubtedly be referred to the genus *Lagotia* Wright described in "Pritchard's Infusoria," and figured on Plate 31, Figs. 7–13. His description of *L. producta* is as follows :

"Neck of sheath exceedingly prolonged, annulated sheath of a pale yellow-brown color. Animalcule (= zoöid) two or three times the length of the sheath, attenuated ; ciliated lobes erect, divergent, and re-curved at tips ; color of zoöid, deep blackish-green.

"Dr. Wright observed the development in this species of ciliated embryos, which, after passing through the stages seen in Figs. 2 *a*, *b*, *c*, and carrying on an active existence as free ciliated animals, form an attachment to some surface, and proceed to develop a sheath and the characteristic ciliary lobes. The transformation from ciliated embryos to *Lagotia producta* transpired in the course of a night, the sheath even during that time being completed with its rings."

I have given Dr. Wright's history of *L. producta*, as it is the nearest to *L. cæruleus*, and answers for it with the following exceptions : *L. cæruleus* is of a delicate blue throughout—sheath and body ; *producta* sheath "pale yellow-brown ; body, blackish-



CORDYLOPHORA LACUSTRIS.

green." *L. cæruleus* is found in brackish waters, *L. producta* is a marine form.

L. cæruleus possesses, moreover, a strongly defined median line in each of its lobes, but no such line is shown in Pritchard.

No vent is mentioned by Wright in any of the species of the genus, viz.: *L. viridis*, *hyalina*, *atro-purpurea*, and *producta* ; there is one in *cæruleus*, by which excrement is voided, at the base of the lobes, but it can only be seen when in action.

URNATELLA WALKERII sp. n. (Pl. 29, Fig. 3).

The polyzoön represented in Fig. 3 I have characterized as *Walkerii* after my friend who was with me when it was captured. It is a pretty and very polite form, very shy, and about the one-thirtieth of an inch in length when extended. Its politeness consists in very frequently bowing body and stem from its base, and then returning to an erect position.

It is almost identical with *U. gracilis* Leidy, save that *gracilis* has several constrictions in the stem, whilst *Walkerii* has the stem perfectly plain and somewhat tapering. Leidy says of *L. gracilis*: "The longest stems consist of a dozen joints, and measure about

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Explanation of Plate 31. (After Allman.)

Cordylophora lacustris. FIG. 4. Portion of the walls of the stomach highly magnified *a*. Ectoderm, its cells containing thread-cells. *b*. Endoderm composed of elongated cells, with true secreting cells in their interior. *c*. Secreting cells with evident nucleus. *d*. Secreting cells with nucleus obscured. *e*. Granular mass. *f*. Muscles.—FIG. 5. Thread-cells before exsertion of filament.—FIG. 6. Thread-cells after exsertion of filament.—FIG. 7. Cells liberated under pressure from the ectoderm, some with a thread-cell, others with a nucleus.—FIG. 8. Cells liberated by pressure from endoderm of stomach.—FIG. 9. Portion of tentacle near its root. *a*. Ectoderm with thread-cells. *b*. Endoderm. *c*. Muscular fibres.—FIG. 10. Cells containing secondary cells from endoderm.—In FIGS. 11-14 the letters indicate : *a*. Diverticulum from the cœnosarc. *b*. External investment of the reproductive capsule. *c*. Cellular sac. *d*. Ramified canals. *e*. Structureless sac secreted outside of the cellular sac.—FIG. 11. Reproductive capsule, very early stage.—FIG. 12. The same, more advanced.—FIG. 13. Ideal longitudinal section of the same at the same stage.—FIG. 14. The capsule more advanced the ova being visible.—FIG. 15. The same still further advanced, the ova lying on the extremity of the diverticulum.—FIG. 16. More magnified view of ovum, segmentation into a mulberry-like mass.—FIG. 17. Capsule still further advanced, ova elongated.—FIG. 18. The same, ova swarming in interior.—FIG. 19. The same. sac ruptured. ova escaping as free ciliated infusoria.—FIG 20. Embryo just after escape.—FIG. 21. The same, assuming pyriform figure.—FIG. 22. The same after locomotive stage, fixed by one extremity.. FIG. 23. Further development. tentacula budding, stem surrounded by a delicate polypary.—FIG. 24. Male capsule. *a*. Contents escaping under slight pressure. *b*. Caudate cells liberated from capsule. *c*. Spermatozoa.

the one-eighth of an inch in length ; the shortest stems have one-third the number of joints." From the construction of the stems he further argues: "As in the other fresh-water polyzoa, the polyps die on the approach of winter, but the headless stems appear to remain securely anchored and ready to reproduce the polyps in the spring."

From my short acquaintance with the new form, I am not at present able to confirm or reject Leidy's theory; but he was a very careful observer, and his recent death was a great loss to science.

In *U. Walkerii* the tentacula are from eight to ten in number, and unusually short and stumpy, with thirty or forty cilia on each side. There is an upward circulation—shown in the left of the figure—a crushing apparatus in the œsophagus, whilst the gizzard performs its functions with a quick revolving motion.

OCTOCELLA LIBERTAS sp. n. (Pl. 29, Fig. 4).

This beautiful little polyzoön I have named *Octocella* from its possession of eight tentacles, and *libertas* in recognition of its being found in the shadow of the Statue of Liberty.

The process known as "introversion" is remarkable in this form, whilst it is also a fine example of ciliary action. It is, when extended, very clear, and is provided with a crushing apparatus in the œsophagus, by which the food is prepared for the action of the gizzard beneath. But the structure and mode of reproduction in the Polyzoa have been so frequently and so fully described by able writers that it would be presumptuous in me to enter the lists, unless our small friend should manifest some undescribed peculiarities.

CORDYLOPHORA CORONATA sp. n. (Pl. 29, Fig. 5).

This member of the group Hydroida must at once take rank as one of the most attractive forms I have beheld in an experience of thirty-five years. As it seems hardy, it is a very valuable addition to our "exhibition objects." I have now in my aquaria some of my original gathering, made more than two months ago.

When first found, as I did not then happen to be one of the select few who have been favored with a sight of *C. lacustris*, it was taken for that form ; but on hunting it up in the *Philosophical Transactions*, 1853, I found that, whatever it was, it was not that,

the number and position of the tentacula alone precluding that possibility.

Like the typical Hydra, it rises on an elongated stem, and extends tentacles armed with bundles of thread-cells, also Hydra-fashion; but then all resemblance ceases. Its tentacles range from twelve to thirty in number, and spring from a continuous ring around the upper portion of what may be called the head, and just below the mouth. A short distance from the base they are connected by a beautifully delicate "web," thus forming a perfect funnel (see Fig. 5*a*, which is a view from above). This web-like joining of the tentacles doubtless aids in their more rapid contraction when alarmed, and would seem to foreshadow the similar connection shown in *Plumatella* and other polyzoöns. Notwithstanding their number, and the absence of highly developed muscular power as seen in the Rotifera and Polyzoa, they appear to be under absolute control.

The thread-cells are very numerous, ranging from eighty to one hundred bundles on each of the tentacula. I have reason to believe that reproduction is effected in a similar manner to that of *C. lacustris*. Indeed, I have already noted some points of resemblance, and when my observations are completed I hope to have the pleasure of laying them before the Society.

Cordylophora Lacustris Allman (Pls. 30, 31).

I have now to narrate a singular coincidence which occurred in connection with the discovery of the preceding forms.

Whilst looking over my stock of *C. coronata* I noticed one different to all the rest, and on fishing it out and giving it time to recover from its surprise, to my utter amazement I found I had before me a solitary specimen of *C. lacustris*. As I have before said, I had not previously seen it nor Dr. Allman's memoir, and should not have known it but for my recent searches and the drawings I had made.

Had a choice been given me, it would have been this form above all others, and more especially for the purpose of comparison; and, therefore, my pleasure on seeing it gradually unfold itself in all its beauty can be more easily imagined than described. Fearing I might lose it, I exhibited it, without remarks, at the Society's meeting on November 6th, 1891.[1]

[1] This specimen was exhibited by Mr. Horace W. Calef for Mr. Helm.—Ed.

As *C. lacustris*—according to Dr. Stokes—has only been found three times before in this country, twice by the late Prof. Leidy and once by Mr. Carter of Johns Hopkins University; as Dr. Allman's paper is the only standard authority upon it, and almost as rare as is the animal itself; and believing it will be fully appreciated by microscopists generally, and at the same time afford a convenient opportunity for comparison with the new form, the authorities of the Society have kindly consented to reproduce the plates of Dr. Allman's paper, as read before the Royal Society, and published in *Phil. Trans.* for 1853.

The only additional remark I have to make is on the difference between my illustration of the perfect animal, and Dr. Allman's. My drawing is an almost exact reproduction—making some allowance for perspective—of the position of its twelve tentacula during the fifteen days I had it under observation. As it lived so long, I was indulging the hope that it might bud and multiply; but when it did collapse, in a few hours there was no trace of its existence left behind. Never did I so sincerely mourn the loss of a specimen, and although I spent many, many hours in searching, I could not find another.

NOTE.—Since the reading of this paper I have met an article by the Rev. Thomas Hincks, B.A., published in the *Popular Science Review* for 1870, describing a polyzoön named *Valkeria pustulosa*, which in some respects very closely resembles *Octocella libertas;* but the woodcut is very indistinct, whilst there is no mention made of a tube. If Mr. Hincks be living, perhaps he may be able to throw some light on the subject.

PROCEEDINGS.

Meeting of December 4th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Seventeen persons present.

Messrs. Stephen Helm and Alfred Kroger were elected Resident Members.

Mr. Walter H. Mead, chairman of the Committee on Nomination of Officers, presented the report of the Committee, nominating officers for the coming year.

The Corresponding Secretary read a communication from Mr. G. R. Lumsden, of Greenville, Conn., donating to the Society a packet of diatomaceous material from a peat bog at Amherst, Nova Scotia.

On motion the thanks of the Society were tendered Mr. Lumsden for this donation.

Dr. N. L. Britton read a paper entitled "The North American Species of the genus Scirpus." This paper was illustrated by many herbarium specimens, and the fruit of two species under microscopes, as noticed in the programme.

Mr. Stephen Helm read a paper entitled "*Cordylophora lacustris* and five new forms of Animal Life." This paper was illustrated by original drawings and by objects under microscopes, and is published in this number of the Journal, p. 43.

OBJECTS EXHIBITED.

1. Head of the Spider, *Attus tripunctatus* Hentz, female, showing the eight eyes, palpi, falces, and fangs: by J. L. Zabriskie.

2. Section of an Ammonite from Würtemberg, Germany, being a cast composed of iron pyrites: by J. D. Hyatt.

3. Section of Agate, regular greenish aggregations covered with a dense pubescence: by J. D. Hyatt.

4. "Slug-form" of aquatic life, designated as "No. 1": by James Walker for Stephen Helm.

5. *Cordylophora coronata* n. sp., from the Morris & Essex Canal: by Stephen Helm.

6. Achene of *Eleocharis mutata:* by N. L. Britton.
7. Achene of *Scirpus microcarpus* Presl.: by N. L. Britton.

Meeting of December 18th, 1891.

The Vice-President, Mr. J. D. Hyatt, in the chair.

Thirty-three persons present.

Mr. Charles F. Cox delivered a lecture entitled "What is a Diatom?" This lecture was illustrated by one hundred stereopticon projections of diatoms, and is published entire in the January number of this volume of the Journal.

On motion the thanks of the Society were tendered Mr. Cox for this interesting, valuable, and beautifully illustrated lecture.

On motion it was resolved that when the Society adjourns it adjourn to meet on the evening of January 5th, 1892.

Meeting of January 5th, 1892.

The President, Mr. P. H. Dudley, in the chair.

Twenty-eight persons present.

Prof. Henry M. Rusby, M.D., and Mr. J. W. Lloyd were elected Resident Members.

The Annual Reports of the Treasurer and the Committee on Publications were presented and adopted.

This being the designated time for the election of officers, the chair appointed Dr. Edw. G. Love and the Rev. Geo. E. F. Haas tellers, and at the close of the polls the following persons were declared elected as officers of the Society for the coming year:

President, J. D. Hyatt.
Vice-President, Charles S. Shultz.
Recording Secretary, George E. Ashby.
Corresponding Secretary, J. L. Zabriskie.
Treasurer, James Walker.
Librarian, Ludwig Riederer.
Curator, George E. Ashby.
Auditors, F. W. Devoe. W. E. Damon. F. W. Leggett.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, dated Mobile, Alabama, December 4th, 1891, donating slides and material to the Society as follows:

"The slides and rock specimens are sent with the view of putting on record some new discoveries in microgeology of this character. Some years ago I donated a thin section of an indurated silicious sedimentary rock which I regarded as a tripoli, as the specimen seemed to show innumerable spicular spaces filled with air. I also sent smoothed specimens to exhibit the superficial aspect as opaque objects. I even then suspected that the rock contained polycistinous bodies. While in Meridian, Miss., during last October, I secured additional specimens of the rock, varying in density. A few days ago it occurred to me to test what I could find in the way of remains of Microzoa in the softer and chalkier specimens. I brushed down in water the surfaces of three different pieces, and was gratified by finding Polycistina and curious sponge spicules, gemmules, and plates of silex containing acicular inclusions. In pursuing this work I made the experimental slides sent to the Society, and on each slide I have noted with a small dot of india ink the situations of various specimens of Polycistina. About seventy-five organisms are shown.

"In the rock specimens sent there are three grades of hardness, and the two soft specimens were used by me in securing the specimens on the slides. The material occurs in great stratified beds with horizontal planes, which are shown very numerously in Clarke Co., Miss., north of Enterprise, in the deeper cuts of the Mobile & Ohio Railroad.

"Some years ago, in attempts to make magnifying glasses, I gave the optical polish to the lenses with this same tripoli stone scraped to a fine flour. I believe the slides will demonstrate something entirely new in the microscopical material line, as I have reason to believe that the composition of this rock had not been previously determined under micro-analysis by any one even in the State of Mississippi."

On motion the thanks of the Society were tendered Mr. Cunningham for these donations.

The President, Mr. P. H. Dudley, delivered his Annual Ad-

dress, entitled "Structure in Steel," illustrated by numerous specimens.

OBJECTS EXHIBITED.

1–35. Specimens of Steel, illustrating the Annual Address: by P. H. DUDLEY.

36. Polycistina from Enterprise, Miss., prepared and donated to the Society by Mr. K. M. Cunningham: by J. L. ZABRISKIE.

37. A new Microscopical Lamp, manufactured by James Stratton & Son: by J. L. ZABRISKIE.

38. Transverse section of stem of Wistaria, double stained: by FRANK D. SKEEL.

39. Transverse section of quill of Porcupine, double stained: by J. D. HYATT.

Mr. Zabriskie remarked concerning the microscopical lamp invented and manufactured by James Stratton & Son, 207 Spencer street, Brooklyn: It is remarkable for its compactness, its ease and variety of adjustments, its efficiency, and its very moderate cost. It stands upon a marbleized slate base three and one-half inches square. From one corner of this base rises a firm metal post three inches in height. A joint at the upper extremity of this post carries a two-jointed metallic arm, which in turn supports a bull's-eye lens nearly three inches in diameter, and the lamp-bowl surmounted by its glass chimney and japanned metallic shade. All the metal parts, excepting the base, burner, and japanned shade, are nickel-plated. The range of motion in the two-jointed arm, and the angle at which the lamp-bowl can be safely inclined when elevated, give a surprising variety of elevations and inclinations for the body of light passing through the bull's-eye. Discs of ground and blue glass are supplied for the conical opening of the metallic shade, which discs can be adjusted or removed with the greatest facility. The metallic shade fits loosely upon the burner of the lamp, and is also separate from the metal mounting of the bull's-eye. So that the varying effects of light, from the flat side or from the edge of the flame, can be obtained by merely revolving the lamp-bowl, while the shade, the bull's-eye, and all the appliances of the microscope itself remain in their last appointed positions. And further, if light is desired momentarily upon the table, it is only necessary to revolve

the metallic shade alone, and space near the hands, or of any other reasonably required position, can be instantly illuminated without disturbing any other adjustments. It is evidently a most desirable and satisfactory lamp.

Meeting of January 15th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Thirty-three persons present.

The following appointments were made by the chair:

Committee on Admissions: F. W. Devoe, William E. Damon, George F. Kunz, William Wales, F. D. Skeel.

Committee on Publications: J. L. Zabriskie, William G. De Witt, Walter H. Mead, John L. Wall, Charles F. Cox.

F. D. Skeel and Walter H. Mead were added to the Committee on Annual Reception.

Dr. A. A. Julien read a paper, entitled "A Fungus in Silicified Wood from Arizona and Texas." This paper was illustrated by twenty-three photomicrographs and by objects under microscopes, as noted below.

OBJECTS EXHIBITED.

1. Galvanoplastic reproduction of the Permian Reptile, *Seeleya pusilla*, from Bohemia.
2. Restoration in bronze of the complete Reptile.
3. Artificial Rubies, and thirteen prints illustrating Rubies.
4. Piece of a crucible used in the manufacture, with Rubies adhering.
5. Entomological preparations in solution, by Dr. Fischer, of Bohemia, showing the developing stages of a Cockchafer, from the egg to the imago.
6. Preparations in solution, by Dr. Fischer, of Termites in all stages.
7. Angle-measuring apparatus by Fuess, of Berlin.
8. "Dreh-Apparat," devised by Prof. C. Klein, of Berlin.
9. Small pocket lens made of Feldspar.
10. Specimens of thin Quartz, which when pressed with a pin-point always break into the rhombohedral cleavages.
11. Prism made of crystal of Iceland Spar.

12. True Ruby in matrix of limestone from Burmah.

13. Artificial Emeralds.

14. Rainbow Agate.

15. Zuñi Bread.

16. The new Nachet Grand Petrographical Microscope, with Dr. Koch's Microscope Lamp.

Exhibits 1–16 all by GEORGE F. KUNZ.

17. Macrospore of *Siderothrix* in Silicified Wood: by A. A. JULIEN.

18. Macrospore germinating in Silicified Wood: by A. A. JULIEN.

19. Crystals of Calcium Oxalate in Silicified Wood: by A. A. JULIEN.

20. The parasitic Wasp, *Hyptia* sp.: by J. L. ZABRISKIE.

Mr. Kunz furnished the following explanation of his exhibits:

"The researches on the production or synthesis of the ruby have been carried on in the laboratory of the Musée d'Histoire Naturelle of Paris from 1887 to 1890, and to some extent since then. In the first work published by them, M. Fremy and M. Verneil announced that they had obtained rubies approaching a lively red color, made in a crucible of refractory porcelain containing a mixture of aluminate of lead and bichromate of potash, the silica of the crucible uniting with the lead of the lead aluminate and forming a fusible silicate of lead, and the alumina crystallizing as rubies. The crystals formed in quantity and were of a good rose color, but were always lamellar and friable.

"In a second work published by them, it was announced that they had made transparent rubies that were brilliant, crystallizing as rhombohedrons, the crystals being of a purity equal to that of natural rubies. These were made in a refractory crucible, at a high temperature, containing a mixture of alumina with a little potash, fluoride, or barium, and bichromate of potash. It was found indispensable to pass a current of air through the crucible. The alumina combined with the potash and the air passing through the crucible, causing at a very high temperature the hydrofluoric acid to separate from the barium and form an alkaline fluoride, the rubies remaining in a state of absolute purity in a matrix of alumina.

"Every time the fluoride or alumina was elevated to a tempera-

ture of 1,500° C., the influence of the humid air always caused the formation of the rubies and the separation of the hydrofluoric acid. And at the close of their studies on the Synthesis of the Ruby they announce that rubies can be made in two different ways: by the decomposition of the alkaline aluminate by the influence of hydrofluoric acid, or by merely heating the fluoride of aluminum to a temperature equal to that of its disintegration.

"The illustrations which I exhibit this evening I have taken from 'The Synthesis of the Ruby,' by E. Fremy, 1891, 4to, page 58, plate 21, published by Vve. Ch. Dunod, Paris. Some of the largest rubies figured on these plates have been magnified sixty diameters, *hence their true diameter is from one to two millimetres*—one-twenty-fifth to one-twelfth of an inch. M. Fremy did not succeed in obtaining crystals weighing more than fifty-five milligrammes—one-fourth of a carat—each, before cutting, and the rubies, in the jewelry figured on these plates, were natural crystals, not cut gems. *Up to the present time he has not produced rubies of sufficient size to warrant their sale in the gem markets.*

"Prof. Dr. Anton Fritsch, Director of the Royal Geological Survey of Bohemia, has prepared, in all, two series, by the galvanoplastic process, of reproductions of the Permian reptiles of Bohemia. Many of these are exceedingly small, and the markings of their remains in the rocks are very delicate. The smallest and most interesting of the group is the *Seeleya pusilla*, which I show this evening under a three-inch objective. The entire reptile measures less than one inch in length. Dr. Fritsch has also restored twelve of the more important reptiles, and has arranged them on a fac-simile of Permian rock. Under a three-inch objective the complete reptile is shown, the dentition being remarkably perfect, as well as all the vertebræ and the feet. A photograph of this I have brought with me this evening, and also one of the isolated reptiles—*Ricnadon*—of this group.

"The optician, Ivan Werlein, of Paris, while making some plates of quartz for a new galvanometer, found it necessary to cut these sections parallel to the rhombohedron, making the sections the thinness of less than one-tenth of a millimetre, or one-two-hundredth of an inch, of three inches in length and one-half an inch in width. These plates of quartz were coated on the one side by a thin deposit of silver, the current being measured

by the deflections of the plate. Of great interest is the fact that these thin plates of quartz, when punctured by a pin or needle-point, separate with rhombohedral cleavages, showing that quartz, the cleavage of which is otherwise never very facile, when prepared in these sections is one of the most highly cleavable of all minerals.

"To increase the sensibility of the tourmaline forceps, Werlein has attached to one of the tourmalines a small condenser of didymium glass, producing excellent results.

"Dreh-Apparat—turning apparatus—devised by Prof. C. Klein, of Berlin, and made by Fuess, of Berlin. Described in *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin*, Sitzung der physikalische-mathematischen Classe vom 30. April. 'Krystallographisch-optische Untersuchungen. Ueber Construction und Verwendung von Drehapparaten zur optischen Untersuchung von Krystallen in Medien ähnlicher Brechbarkeit,' von Carl Klein, pages 1 to 10. Used to examine entire crystals, fragments, and minerals cut into gem form, under the polariscope and microscope.

"Axis-measuring apparatus on the Adam principle, made by Fuess, of Berlin, Germany, for examining the optical properties of minute scales of fragments of minerals. Described in *Ueber Mikroskope für Krystallographische und Petrographische Untersuchungen*, von R. Fuess, Berlin, S. W., 108 Alte Jacob Strasse, pages 25 to 28, 1891.

"In connection with these two pieces of apparatus, I would remark that Pulfrich gives a list of twenty-six liquids of varying refractive indices, 1.5381 dispersion equalling 0.0142 to iodide of mercury dissolved in aniline and chinoline refractive indices 2.2, and when dissolved with lepodine a still higher index.

"Pocket lens, one-fourth inch, made of oligoclase feldspar from Bakersville, North Carolina, described by George F. Kunz in *Amer. Jour. of Sci.*, series iii., vol. xxxvi., page 222.

"Artificial Ruby, made by E. Fremy. Two series of slides of detached crystals, and one piece of crucible with rubies adhering. Described by E. Fremy in 'Synthesis of the Ruby,' Paris, 1891, page 58, plate 21, published by Vve. Ch. Dunod.

"After listening to Dr. Julien's paper, I would state that I visited the localities last summer, and conform with the observa-

tions made by Dr. Julien, that the formation in which the wood is found is of considerable extent, and has been traced in New Mexico and Arizona for some hundreds of miles, and had been referred to the Chinarump Group of the Jura Trias by Major J. W. Powell. My observations of the locality lead me to the conclusion that silicious water was the silicifying agent. The trees, having fallen into water, had partly rotted, and only after sinking in the swamp, lake, or river had silicification set in. The trees on the lower levels in the so-called parks did not really belong there, nor had they come from any of the layers of rock from the same level, but from the top strata, in some places one hundred feet above where they lie at present. I observed trees *in situ* only in this upper layer. One tree *in situ* measured over one hundred feet in length. From the total absence of roots and branches and bark, I conclude that the wood had not been silicified in the same manner as the agatized woods of Yellowstone Park and Colorado, where the logs or trees are generally hollow, inasmuch as all the Arizona trees must have silicified in a recumbent position, having fallen in some unknown lake, sea, river, or swamp. And, further, that as there was no bark on any of the trees, they must have rotted, and in some of the masses examined at least four or five inches of the bark and outer rings of the tree were missing. They were silicified in water highly charged with oxide of iron, the red or yellow color varying according to the amount of oxide present, probably by decomposition of a variable amount of vegetable matter. The presence of the fungus *zoöglia*, described by Dr. Julien, has probably induced the precipitation of silica from the water in which the tree trunks lay."

Mr. Zabriskie said of his exhibit: "This small parasite, collected at Fisher's Island, L. I., is one of the most curiously formed parasitic wasps of our fauna. The slender petiole of the abdomen, instead of being placed in the usual position, is inserted high up on the back, at the base of the metathorax. The abdomen is greatly compressed, and the area of its side is only one-fourth of the corresponding area of the thorax, causing the abdomen to appear ridiculously small. The anterior wings possess only one cell—the costal cell—and are furnished with costal, subcostal, and basal nervures, and with a prominent

stigma. The abdomen is so highly polished that, when looking in the microscope, the observer can see, reflected from the side of the abdomen, a perfect inverted image of the body of the microscope, the observer's head, and any object near it, especially the hand, when moved near the face.

"In a case is also exhibited another species of *Hyptia*, collected at Flatbush, L. I., differing in coloration, but quite similar in size and form to the first specimen. Also in the same case a specimen of *Evania appendigaster* L., collected in the City Hall Park, New York City. It will be seen that this *Evania* resembles very closely the two specimens of *Hyptia* in general form and in the insertion of the petiole of the abdomen, but it is of twice their size, differs in the neuration of the wings, and has the posterior legs relatively much longer.

"Only one species of *Evania* is recorded for the United States, and it is parasitic on the cockroach. Three species of *Hyptia* are recorded for the United States, but their habits are not reported."

Meeting of February 5th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-one persons present.

The Corresponding Secretary read the following communications from Mr. K. M. Cunningham, of Mobile, Ala., accompanying donations to the Society :

"January 15th, 1892.

"EXPLANATORY NOTES ON SLIDES DONATED TO NEW YORK MICROSCOPICAL SOCIETY.

"Two slides of fresh-water diatoms, derived from subsoil at Tuscaloosa, Ala., within a park enclosure facing grounds of Alabama Asylum for the Insane ; material excavated from a drainage ditch through the oak grove. The associated species are few, viz. : *Navicula viridis*, *Stauroneis phœnicenteron*, *Nitzschia amphioxys*, *Eunotia diodon*, and sponge spicules ; the locality is the site of a former muck basin ; the deposit may be said to be common to all low drainage areas about Tuscaloosa

traversed by spring branches, the formed earth carrying a large proportion of vegetable débris.

"Five slides illustrating vegetable or plant structure in Alabama coal; all of the specimens being derived from a non-coking, semi-bituminous coal from the Deer Creek coal vein, Walker Co., Ala. This variety of coal burns quietly, without bituminous intumescence, thus leaving foliated plates of a whitish shale, which can be readily separated into thin pellicles, and from these pellicles there can be isolated two specific kinds of vegetable structures, derived from stems, branches, or trunks of coal-forming plants; and a third kind of vegetable structure, shown in tlide labelled 'Fossil Sporangia.' When isolated from the burned coal shale in their unbroken state, they are very minute, oval, scale-like porcelain plates, having a collapsed appearance, and when first enclosed in balsam show numerous dark annular spaces which become semi-transparent rings when the air is expelled from the sporangium. These minute bodies may be construed as a key to one of the associated phenomena of the formation of coal strata in geologic time, in this wise: they aid in proving that coal is a sedimentary aggregation of microscopic plant particles, in connection with larger or grosser vegetable particles, readily visible to the eye, such as the seal-like impressions of Sigillaria stems, the fossil 'charcoal' commonly seen on the deposition layers of the bituminous coals of Alabama, and in the pyritized shales occurring interbedded in the coal, which show clearly vegetable structure in profusion, but of little structural interest under the microscope. An analogy between the formation of coal strata, recent marine muds, and fossil diatomaceous strata has, by the discovery of the fossil sporangia in coal, been suggested to me, in this sense: that in all preliminary cleanings of Mobile Bay marine muds, of the marsh muds, and of the several fresh-water fossil diatomaceous earths recently examined by me, there is a moderate proportion of vegetable débris of plant tissues, but more particularly and invariably an abundance of coniferous or pine-pollen grains, which are of such a special bilobated structure as not to be readily confounded with any other organic structures, vegetable or mineral; and as these pine-pollen grains are abundant in the Montgomery, Ala., diatomaceous earth, which is also exceedingly rich in fresh-water diatoms,

and its period of deposition antecedent to that of the overlying gravel beds and alluvial sands, the association of the pollen grains with the diatoms proves them to be of contemporaneous growth and deposition; and the survival of the pollen from decay may be attributable to their resinous nature, which is likewise a characteristic of the spores of the present fern-vegetation of the earth, as well as that of the carboniferous period in geology.

"One slide of macrospores. These interesting fossil plant remains were isolated from a shale from Ontario, Canada, by crushing the shale transversely to its layers. Under a high power they show spinous processes regularly distributed over their surfaces. When a single specimen is ignited on mica, it melts to a shapeless bituminous mass and is reduced to ash. The slide is sent for comparison with the fossil sporangia from Alabama coal.

"Four slides derived from a study of material from borings of a now celebrated artesian well at Mobile, Ala., 850 feet in depth, recently finished. One shows a group of forty foraminifera of a single species, being very nearly the only microscopic animal remains permeating 500 feet of greensand strata. Two of the slides show a sand of high specific gravity, composed of myriads of spherules, octahedral and dodecahedral crystals of pyrite, also perfect microscopic quartz crystals, polished agate and sand grains, and grains of magnetite, all associated together. One slide of magnetite grains, including iron scales from boring tubes. These grains were separated from the pyrites sand with a small magnet, and as mounted will serve to illustrate a number of interesting experiments under the microscope. For example, when the grains are evenly scattered on the slide the effect of the union of the grains may be noted when a small horseshoe magnet is applied to the under side of the slide. If one leg or pole is presented, the grains stand in vertical chains; and if the magnet is moved in rapid circles, double or multiple images of the grain chains succeed each other in waltzing style; if the slide is held in a vertical plane, and both poles applied to the cover glass, a single chain of grains is lifted to top of cell and drops at once on removal of the magnet. The grains may be scattered by tapping with the thumb nail, and each grain may be examined for mineralogical character. When this pyrites sand is heated

red-hot, the crystals and spherules of pyrite are turned to a red oxide soluble in water. Grains not soluble are attracted by the magnet, while as unburned crystals of pyrite the magnet has no influence on them.

"Four slides to illustrate and place on record for the first time the occurrence of a new deposit of tripoli, being a marine fossil sedimentary rock recently discovered by me, its true character having been misunderstood until I demonstrated it by microscopic analysis. Its geographical position is indicated as follows: It occurs at the Big McGrew's Shoal on the Tombigbee River, Clarke Co., Ala., one mile by land northeasterly from St. Stephens, or three miles by river. This shoal is now being blasted out and improved under Government supervision, and specimens of the different rocks forming the obstruction were forwarded to U. S. Engineer's office at Mobile, where I casually found it. At this time it seems to have an unique interest, as I know of no other rock or tripoli similar to it in mineral or fossil composition. Its uniqueness lies in the fact that it is a tripoli that breaks down easily to a mud in water, and is very rich in marine fossil Diatoms, Polycistina, Foraminifera, sponge spicules and gemmules, plant débris, and mineral grains, notably crystalline chloritic grains; and that the Diatoms, Polycistina, and Foraminifera are infiltrated by transparent mineral, decussating, crystalline plates, not readily soluble in acids, thus nearly obliterating the sculptural markings on their surfaces, and thus practically being *petrified* Diatoms, Polycistina, and Foraminifera. The slides sent were made by rubbing the dry tripoli powder, after cold acid treatment, on chamois skin, to remove the undesirable amorphous particles of silica. The Diatoms, Polycistina, and Foraminifera survived this polishing ordeal, thus attesting their toughness through petrifaction. Species of the following genera may be seen on the slides, viz.: *Coscinodiscus*, from very large to small species; *Triceratium*, triangular and square forms; and a *Biddulphia* and *Cyclotella*. The Polycistina and Foraminifera do not require special mention. The reticulation on the *Coscinodisci* can be made out with a one-sixth objective and good daylight. Another matter of interest that this new find revives is the fact that Dr. C. G. Ehrenberg, in his 'Micro-Geologie,' listed many of the living fresh-water

diatoms from the Tombigbee River and Sintabogue Creek in this immediate neighborhood, but must have failed to get samples of this marine tripoli, as it would have been a 'capital prize' on account of its richness in organic fossil remains.

"One slide showing a thin section made from an opalized or indurated form of the same tripoli stone referred to above.

"I followed the borings of the artesian well in the hope of corroborating the occurrence of marine diatomaceous clays, such as occur on the Atlantic seaboard artesian-well area, but found the various strata, penetrated to a depth of 850 feet, absolutely void of diatomaceous forms. The last stratum of clay penetrated, before reaching the water sands, contained plant débris and fossil pollen grains alone. Bits of amber and pieces of pyritized coniferous wood and lignite were freely washed up, and generally secured by the curious spectators at the completion of the well.

"I forward also several specimen packets of the crude material from which most of the slides commented upon herein were made."

"JANUARY 20TH, 1892.

"I mail with this a package of raw material:

"1. A piece of coal shale—burned—from Deer Creek, Walker Co., Alabama coal. With an inch hand magnifier an abundance of the fossil sporangial bodies may be seen *in situ*. It is from this coal that I prepared the slide showing the spores in the fossil sporangial capsules, on the slide labelled 'Fossil Sporangia.'

"2. A specimen from the recently discovered locality in Clarke Co., Ala., near St. Stephens, of which I sent the Society four prepared slides of a new tripoli of the marine sedimentary class of rocks. The stratum belongs to the cretaceous rocks of Alabama.

"3. A packet of the pyritous sand and micro-minerals, of which I sent two slides previously."

"FEBRUARY 1ST, 1892.

"I send the following specimens:

"1. From McGrew's Shoal, Tombigbee River, near St. Stephens, Ala. The rock will interest the diatomist and petrologist, as it is a composite rock of marine sedimentary origin. It

will make a fine polariscope object, as a thin section will probably show Diatoms, Polycistina, Foraminifera, and sections of larger shells, the whole silicified and strongly crystalline in structure. It is from the same formation as the marine tripoli previously sent to the Society.

"2. A cement stone from Sendai, Japan. This was sent me by M. J. Tempère, Paris, joint editor of the 'Diatoms of Yeddo and Japan,' as a return for Montgomery earth. It can be used as thin sections, from which much may be learned of the internal structure of the Diatoms and Polycistina contained therein. Being of a flinty nature, it will take a vitreous polish, bringing out the internal structure as seldom seen in diatom slides.

"3. A piece of coniferous wood, derived from a vein of lignite, ejected from the depth of about 700 feet from the new artesian well recently finished at Mobile.

"4. A piece of genuine lignite coal, also from the artesian well, at a depth of 700 feet. When brushed down in water it furnishes fine slides, showing plant structures: as scalariform tissues, pitted ducts, reticulated tissue, and spores and capsules of several kinds. It is best studied with a high power. The whole is interesting when viewed in its mineralogical relation to bituminous coal and the immense period separating them geologically."

OBJECTS EXHIBITED.

1. Serial sections through the body, next and posterior to the gill covers, of the fish *Atherina* sp., Dotted Silverside: by L. RIEDERER.

2. Serial sections of the vertebral column of the same: by L. RIEDERER.

3. Serial sections of the same, showing gill arches: by L. RIEDERER.

4. Section of fossil Coral: by T. B. BRIGGS.

5. Crystals on under surface of glass covering a daguerreotype taken in 1850: by T. B. BRIGGS.

6. Larva of the wood-boring wasp, *Crabro sexmaculatus* Say: by J. L. ZABRISKIE.

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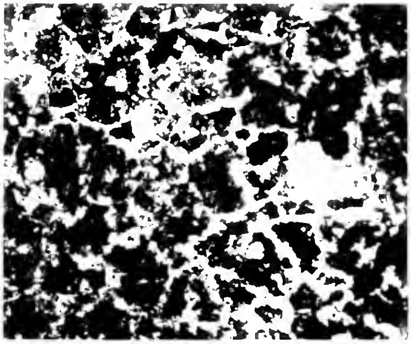

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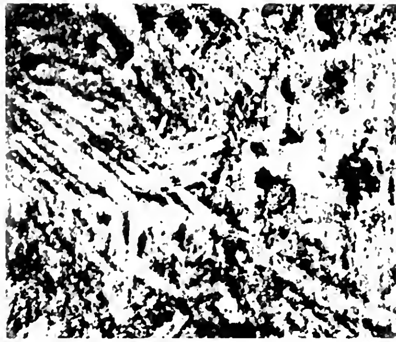

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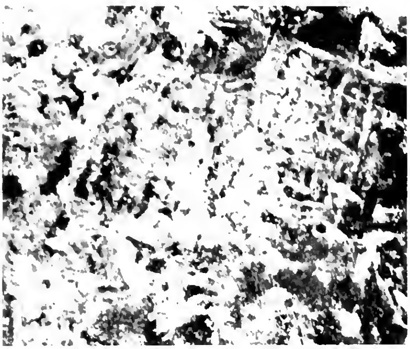

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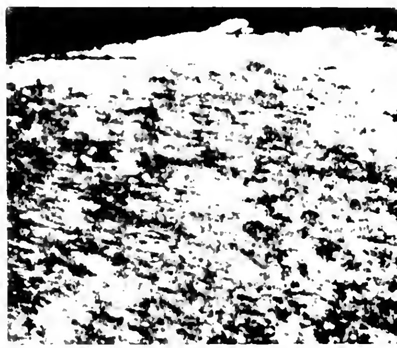

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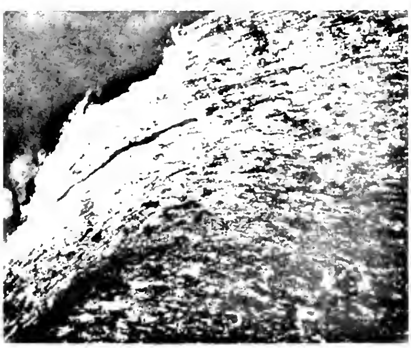

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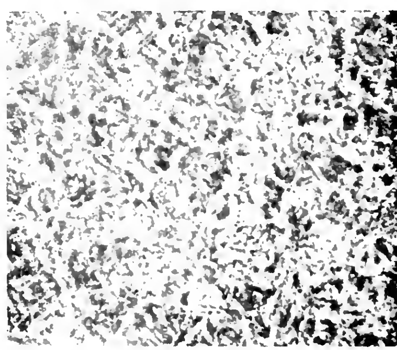

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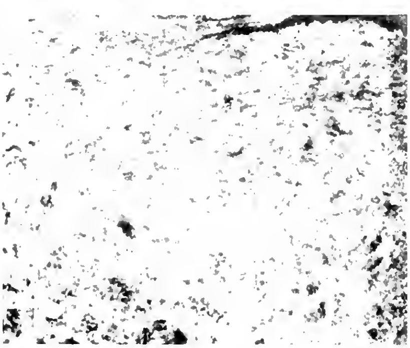

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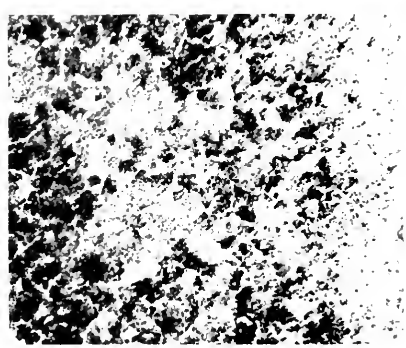

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STRUCTURE IN STEEL.

ANNUAL ADDRESS OF THE PRESIDENT, P. H. DUDLEY.

(*Read January 5th, 1892.*)

Steel being an inorganic compound, the fact is overlooked that when molten the enormous forces of crystallization are only held in check by the intense heat, and, as the steel cools, more or less structure is produced.

Conditions which would affect the fineness or coarseness of texture in rail steel were given in my previous paper upon the same

Explanation of Plate 32.

FIG. 1 is from the exterior surface of a .50 carbon Bessemer rail ingot. The white lines enclosing the mineral aggregates, in this case, indicate more strongly the polyhedral than the columnar structure of the ingot. — FIG. 2 is from a .03 nickel armor plate ingot. The polygonal structure is large, from one twentieth to one-tenth of an inch in diameter. The junction of three polygons is shown near the centre of the figure. The carbide of iron (?) is distributed in thin laminæ, a small amount of the charcoal, work, and heat treatment rendering the steel homogeneous and exceedingly tough.—FIG. 3 is from fluid, compressed, open-hearth steel, after the first hydraulic forging. The carbide of iron is well distributed, though it has not reached the homogeneous condition it will have after further forging and heat treatment.—FIGS. 4, 5, and 6 are from a .26 carbon Bessemer steel rail, from the Boston & Albany Railroad, after ten years' service. Fig. 6 shows the structure in the head of the rail, the polygons being nearly as coarse as in the structure of Fig. 1. The white lines show the distribution of the carbide of iron, while the interior portions of the aggregates are much softer (?), and break down near the upper surface of the rails, from the load of the passing wheels, as shown in Fig. 4, and then flow off to the side of the rail, as shown in Fig. 5, large pieces eventually becoming detached. The structure of the surface of the rail is broken down for one-twentieth of an inch in depth, the rail having lost three fourths of an inch in height in ten years' service. The metal in flowing soon reaches its percentage of elongation, and cracks, or shears from the metal underneath. (See Figs. 4, 5.)—FIG. 7 is from a rail made in 1866, and was in service over twenty years, under heavy traffic. The structure is very fine, and the loads upon the wheels have affected the metal but little over one-hundredth of an inch in depth from the surface.—FIG. 8 is from a .60 carbon rail head, the structure hardly traceable, fine, and dense.

subject. Similar conditions generally apply to other grades of steel, so far as the texture is concerned.

The fact of the great forces of crystallization present in molten steel prevents finding steel after casting to be a homogeneous, structureless compound, but it is composed of several, with more or less structural detail. In other words, our steel ingots are built up of great numbers of mineral aggregates, and to bring the steel into the highest physical condition we must reduce or render the mass as homogeneous as possible and give toughness to the metal as well.

The wonderful and important property of carbon uniting with iron at temperatures below fusion has long been known, especially in regard to tool steels; another property being that this union lowers the melting point of iron and renders it possible to cast it as iron, or, when the carbon is present in lesser quantities, to cast the product as steel.

The first-mentioned property of carbon forms new structure and compounds at different temperatures, or diffuses the carbon in a different manner, and can hold the structure of different temperatures when suddenly cooled.

Another useful property of the compound of carbon and iron is that of hardening upon being heated to a cherry red and suddenly quenching in water, oil, molten lead, and several other similar media. Certain degrees of hardness can be given to steel, according to the use the steel is to subserve.

The same fact seems to be true of the open-hearth and Bessemer steels, and advantage is now taken of it to improve the quality of large masses of steel by heat treatment, as well as depending upon chemical composition and mechanical work. This heat treatment consists in raising the temperature of the steel to the degree which gives the desired structure, and then fixing this structure, which will be hard but more or less brittle, by cooling quickly in some media. To give toughness to the steel it is then annealed at a temperature below quenching. This permits some rearrangement of the compounds. A part of the hardening carbon is converted into cement carbon, which lessens the hardness and brittleness of the remaining hardening carbon.

The results already reached of improving the physical properties of steel of the same chemical composition by heat treatment are

so important that all nations have modified the construction of their ordnance from solid guns to the system of built-up guns, each part not being too large to receive the full benefit of heat treatment.

To illustrate the changes in the structure of steel by mechanical work and heat treatment, I have specimens of open-hearth compressed steel for ordnance—

1. From the ingot.
2. After hydraulic forging.
3. After heat treatment.

These are designated as specimens Nos. 1, 2, and 3.

The steel contains about .40 carbon, and after being poured into the cylindrical ingot mould, 30 inches in diameter and 18 feet long, was put under compression of 2,000 pounds per square inch to prevent the formation of blow holes or a pipe in the ingot. The steel was several hours in setting; many more in cooling, and, notwithstanding the compression, the facets of the imperfect crystals are from one-twentieth to one-tenth of an inch square and distinctly foliated, fracture occurring through this structure instead of through the crystals. In turning such steel under heavy feed the imperfect crystals often tear out instead of cutting through. The tensile strength of such steel rarely reaches 40,000 pounds and has but little elongation in a test specimen. The structure, as shown in specimen No. 1, is very coarse.

Specimen No. 2 is a tensile test bar taken from the steel after heating and forging. Though the coarse structure has been somewhat reduced, the exterior of the bar has a reticulated surface, showing the elongation of the bar is more decided through the foliated structure than through the crystals, and that the steel is not in its best condition.

Specimen No. 3 is a tensile test bar after heat treatment. The tensile strength is over 100,000 pounds per square inch, and the test bar is very smooth on the surface. The crystalline structure has been very completely reduced. The steel has not only high elastic limits, but when they are reached the metal will give many per cent of elongation before fracture occurs. The end of the broken test bar has a decided silky fracture, showing the metal to be very uniform in structure and in excellent condition for severe service, as in ordnance. For projectiles the steel could be much harder.

Specimen No. 4 under the microscope is an etched piece of metal from specimen No. 1 as it came from the ingot. Bright lines forming polygonal structures enclosing the imperfect crystals are quite distinct, while more delicate lines, extending from the polygonal structures into the crystals, can also be seen at a few points. The mottled appearance of most of the interior of the crystals, caused by bright metallic points, may not, in the plane of one etching, be traced to the polygonal lines.

Specimen No. 5 is an etched piece from specimen No. 2. The polygonal lines cannot be traced, because the coarse structure is reduced. The bright lines are abundant and interspersed through the steel in every direction as rather thick laminæ. Specimen No. 2, the test bar after testing, shows the steel to have a rough and reticulated surface on account of not being homogeneous. This is the poor structure of soft rails and those which do not wear well.

Specimen No. 6 is an etched piece from test bar No. 3. The bright lines are no longer distinct, but are well dispersed through the steel, and the structure is homogeneous, which explains the smooth appearance of the broken test bar.

In specimen No. 7—an etched piece of metal from a Bessemer .50 carbon rail ingot by another method of treatment—the lines forming the polygonal structure have been more deeply etched than the other portions of the steel.

The polyhedral structure of the Bessemer rail ingot is very clearly indicated, as specimens Nos. 8 and 9 will confirm. The ingot was not compressed, as that would add largely to the cost of the rails and limit the output. The same objections would apply to subsequent heat treatment of the rails, and we are obliged to resort to other methods of reducing the coarse structure in the ingot to a finer and more enduring one for the rails.

The acid Bessemer process for producing steel is a very rapid one, by blowing air of 25 to 28 pounds pressure per square inch through a bath of molten cast iron in a converter to decarbonize it, though really burning out first the silicon, then the carbon, leaving in the bath the iron partially oxidized, all of the phosphorus, sulphur, copper, and traces of other minerals contained in the ores and fuel. To convert this molten metal into steel of the required grade a definite weight of molten spiegel mixture is added.

This contains the desired carbon, manganese, and silicon to produce the grade of steel desired.

The product is then poured from the converter into the casting ladle, and from the latter into cast-iron ingot moulds of $14\frac{1}{2}$ or 16 inches square, or 16 by 19 inches on the base, as the case may be. These moulds stand vertically in pits and are filled with 4 or 5 feet of molten metal. Chilling and congelation begin as soon as the metal is poured; crystallization forming structure in the ingot, the character of which is dependent upon the grade of the steel, its impurities, size of the ingot, rate of solidification, and particularly the rate of cooling.

In Bessemer rail-steel ingots of $14\frac{1}{2}$ inches or 16 inches square on the base, of the grades of .50 and .60 carbon, the chilling of the exterior surfaces in contact with the mould induces a decided columnar structure, extending at right angles from the mould 1 to 3 inches into the interior of the ingot, then there is more decidedly polyhedral structure to the centre of the ingot. In the upper portion of the ingot a pipe is apt to develop, also gas cavities. In the pipe and cavities traces of crystals are present, the former especially often being studded with perfect forms of pine-tree crystals.

In the blow holes, in the columnar structures of the grades of steel mentioned, I have always found traces of crystallization. There seem to be two systems, in which the main axes are in parallel rows, the lateral axes appearing at right angles to the main axes, forming a series of projecting points at right angles to one another in two directions; in the other system the base of the points seemingly being surrounded by hexagons.

Specimen No. 10 shows the decided columnar structure of the exterior of a .60 carbon ingot. In another specimen of a lower grade of steel blow holes have formed in the columnar structure.

Returning to specimens Nos. 8 and 9, which formed a transverse section from the exterior to the centre of the ingot; the exterior blow holes may be noticed, though the columnar structure has been modified by long-continued heat, while the polyhedral structure has been more strongly developed than usual. The mould could not be stripped from this ingot, and was broken under a drop, and in doing so the ingot was broken. The ingot was many hours in cooling, and quite well-developed octahedral crys-

tals formed, producing a structure which was not strong under shock, fracture taking place between instead of through the crystals. So well-defined structure I have only found in a rail head once and that was the rejected rail from which specimen No. 2, described in my previous paper, was taken. It is a form of structure I do not wish to find either in the ingot or in the rail. Several attempts were made to break up the structure as formed in the rail head, and while a considerable modification was made, removing some of the brittleness of the metal, the structure was not completely effaced. It seems much safer to prevent its formation than to try and break it up afterwards.

In specimen No. 9, of the same ingot, in one of the gas cavities you will see the well-developed pine-tree crystals. The same form of crystals also studded the pipe which formed in the upper part of the ingot.

In the practice of making rails, the ingots as soon as stripped, 8 to 12 minutes after casting, are charged into a reheating furnace or soaking pit to equalize the temperature before blooming. In the latter operation many of the gas cavities and portions of the pipe become closed. The portion of the bloom in which the pipe is not closed is cut out. It is often the case that the interior of the ingot is not fully solidified upon reaching the blooming train, more or less segregation having taken place, producing an ent rely different structure in the centre of the rail. This is not desirable, as the rails are liable to be brittle. Specimens Nos. 11, 12, and 13 are pieces from such rails which failed to stand a drop test of 2,000 pounds falling 20 feet, the rail butt resting upon steel supports of 4 feet span. Before placing the rail upon the supports the base is stamped into inch sections, so the percentage of elongation can be ascertained; any rail failing to give five per cent elongation, the entire rails of the heat are rejected. The carbon and manganese are usually much greater in the central portions of such ingots. In specimen No. 11 the average carbon of the heat was .48 and the manganese .90. In the centre of the ingot the carbon was .60 and the manganese 1.48 per cent. In specimen No. 12 segregation occurred in the metal forming the centre of the head of the rail, the surrounding metal also being weak and easily fractured.

Specimen No. 14 shows a piece of tough rail which was placed

upon the side, the drop of 2,000 pounds falling 20 feet upon the upper edge of base and side of the head, causing the lower edge of the base to elongate 18 per cent per inch for at least 6 inches in length. The rail rebounding from the blocks after the drop struck, it dropped to the foundation of the ingots supporting the blocks, the base wedging between two ingots. The fall of the rebounded drop broke out this piece containing the inch spacings. The fracture in this case is much coarser than would have been the case had the rail failed under the full drop.

Specimens Nos. 15, 16, 17, 18, and 19 are longitudinal sections of pit-test ingots, showing the piping and the gas cavities which are liable to form. In rolling these for bending tests they are not allowed to cool and some of these cavities are closed.

Nos. 15, 16, and 17 are from the same heat of steel, Nos. 15 and 16 being the parts of the same ingot.

Specimen No. 17 is an ingot on which I made the experiment of seeing how much additional carbon would be absorbed by having one side of the mould a plate of carbon. The steel, as poured into the ingot, contained .48 of carbon, was chilled in less than ten minutes, remained in the mould and was cooled in two hours. The first sixteenth inch averaged 1.48 of carbon, the second sixteenth inch .81, and the third was nearly normal. This shows a very rapid and unexpected rate of absorption of carbon, and we can readily understand the diffusion of carbon from the walls surrounding crystals to the crystals, or vice versa, at temperature below fusion. This can also be understood by the process of cementation imparting carbon to iron plates, to make crucible steel. The process of making molten steel take up an additional amount of carbon by absorption permits of graduations of carbon in the same ingot.

Specimens Nos. 18 and 19 are from the same heat of steel, though in No. 18 a small amount (one hundredth of one per cent) of aluminium was added to see its effect upon lessening the blow holes and gas cavities in the steel. The former were reduced, the latter prevented, though the pipe of the ingot was increased. The tensile strength and elongation of the metal were slightly augmented.

With the rapid output of the rail mills, and only 11 passes in the rail trains, it seems important, in order to secure a good

wearing rail of dense metal in the head, to start with a good chemical composition as a basis; the carbon .50 or more; to make a small texture in the ingot; avoid long or over-heating; have a section of rail with a thin head to be well worked, a thick base and heavy web to equalize the heat in the section to give toughness to the metal and not brittleness.

The foliated structure we see between the crystals, and a similar structure which has built them up, become reduced to more delicate laminæ as the imperfect crystals are broken up by mechanical work. The soft steels do not have sufficient cohesion to prevent flow under the loads of the present day. To give such steel strength mechanical work must be done upon the plates, or some elements added which will modify the structure or increase the cohesion of the laminæ.

The first steel rails of only .25 to .4 of carbon, with thin heads, thick bases and webs, made with 23 passes in the rail train, had fine structure in the heads and were excellent rails, though in a few years the sections were not stiff enough for the increasing traffic. Noticing that the rate of wear was very slow in the head, the conclusion was soon reached that massive heads, thin bases and webs would give the longest service. This soon became the style of all new sections. The structure, from a fine one in the heads of old rails, became coarse in the new and wore out at much faster rate. Then a hasty conclusion was reached, from an insufficient investigation, that a small amount of carbon in the rails, low manganese, silicon and phosphorus not exceeding .10, would make better wearing rails than higher grades of steel. We have had an era of massive heads, coarse structure, and soft rails which have not given long service. The metal not only rapidly abrades, but flows, and is forced from the rails. This is illustrated by specimens Nos. 20, 21, and 22. Slower-wearing rails are shown in specimens Nos. 23 and 24, the latter having had double the number of years' service of Nos. 20, 21, and 22.

Specimens Nos. 25, 26, 27, 28, and 29 are some of the sections I have introduced with thinner and broader heads to insure fine structure, as the rails are made by the present rapid methods.

The chemical composition has also been changed to one much harder than formerly, the product in these sections being tough and not brittle. In .60 carbon rails an elongation of 10 to 18 per

cent per inch is secured in the section of the rail under drop tests, often exceeding the elongation of rails much lower in carbon.

It will take many years of experience in the use of high-grade steel rails to convince some people that hard steel can be a material which is tough and not brittle, and one which, when the elastic limits are exceeded, will still elongate to any per cent before rupture.

One of the best illustrations of hard and tough structure in steel is in the modern armor-piercing projectiles. A 6-inch 100-pound conical projectile, fired with a velocity of 2,150 feet per second, striking a steel armor plate with 2,800 foot tons of energy, can be partially embedded therein and rebound with its point hardly dulled or its polish diminished.

Specimen No. 30 is a piece of nickel armor plate steel of fine structure, the tensile strength averaging over 200,000 pounds per square inch, with a limited elongation of 1 to 2 per cent. Only half of this tensile strength is obtained in thick armor plates.

The size and character of the grain in rail steel is a matter of vital importance for the safety and economy of railroad operations. It is the fine texture of the steel rail which has rendered possible the development of our railway system to 163,000 miles of main tracks and 45,000 miles of sidings. In 1890, 1,100,000 tons of steel rails were put into railway tracks, and 3,125,000 tons used for structural purposes. It is hardly a quarter of a century since Bessemer-steel rails were first used to replace iron rails, and in this brief time oceans and continents are crossed, and the nations of the globe are in touch through the fine structure of steel.

LIST OF SPECIMENS.

1. Compressed steel for ordnance, from ingot.
2. Test bar from same steel after the hydraulic forging.
3. Test bar from same steel after heat treatment.
4. Specimen of etched steel from No. 1.
5. Specimen of etched steel from No. 2.
6. Specimen of etched steel from No. 3.
7. Specimen of etched steel from Bessemer rail ingot.
8. Piece of Bessemer rail ingot.
9. Piece of Bessemer rail ingot, showing pine-tree crystals.

10. Columnar structure of exterior portion of the ingot.

11, 12, 13. Webs and flanges of broken rails, showing texture of the metal.

14. Flanges of a .60 carbon rail, showing an elongation of 18 per cent per inch.

15, 16, 17, 18, 19 Sections of pit-test ingots, showing the gas bubbles, blow holes, and piping.

20. Section of worn 72-pound rail from outside of curve.

21. Section of worn 72-pound rail from inside of curve.

22. Section of unworn 72-pound rail.

23. Section of worn 63-pound rail from tangent.

24. Section of worn 63-pound rail from tangent.

25. Section of 70-pound rail, thin, broad head.

26. Section of 75-pound rail, thin, broad head.

27. Section of 80-pound rail, thin, broad head.

28. Section of 95-pound rail, thin, broad head.

29. Section of 100-pound rail, thin, broad head.

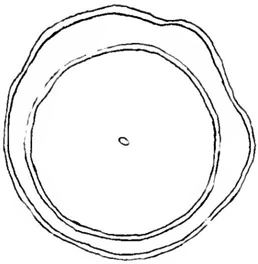
30. Section of 105-pound rail, deep, narrow head.

31. Specular iron ore.

32. Hematite iron ore.

33, 34. Octahedral crystals of magnetite.

35. Spiegeleisen.



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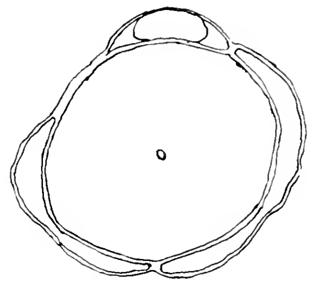

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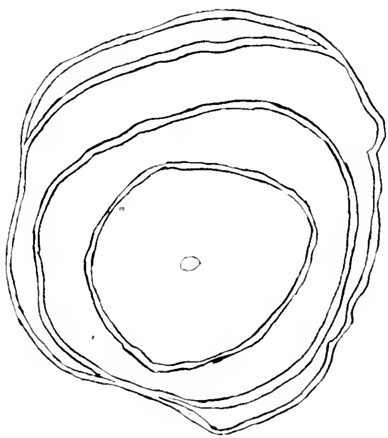

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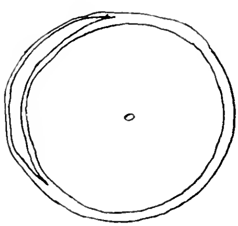

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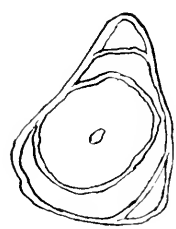

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CURTISS ON WISTARIA.

THE ANATOMY OF THE STEM OF WISTARIA SINENSIS.

BY CARLTON C. CURTISS.

(*Read May 6th, 1892.*)

About a year ago Dr. N. L. Britton received a letter calling his attention to the growth of the *Wistaria sinensis*, and asking an explanation of the apparently anomalous development. Under his direction some study has been given to the anatomical features of the plant with a view to the solution of this question. A gross examination of the anatomy of a transverse section of the older stems (Fig. 1) shows at once a deviation from the normal growths of the phanerogams, but the deviation is not apparent in the younger stems. In the latter the orientation appears normal, the products of the plerom, periblem, and dematogen being perfectly developed and presenting regular growth. For several years, usually twelve or more, this continues, after which time a new cambium zone is formed outside the primary bast and the old cambium dies. Growth now continues normally for a series of years, usually not more than eight. In all cases examined the duration of this secondary growth was several years less than that of the primary. In time this secondary cambium dies and a new one arises with the usual increase as mentioned above. This method of development continues through life, stems twenty-five years old showing four or more bast zones. In stems, however, which have been subjected to pressure while growing and thus have had their symmetrical development checked, the secondary cambium zone appears at a much earlier age, even at the end of the fourth or fifth year.

Such are the apparent features of the plant. A microscopical

Explanation of Plate 33.

FIG. 1. Cross-section of a stem of *Wistaria sinensis* thirty years old, showing three and portions of a fourth zone of bast.—FIG. 2. Cross-section of a six-year-old stem, interlocked with other branches.—FIG. A. Stem twelve years old, showing the beginning of the anomalous growth.—FIG. B. Same stem thirty centimetres below A, showing complete formation of a new cambium.—FIG. C. Cross-section of a seventeen-year-old stem, much twisted and compressed. All the figures natural size.

examination of its anatomy will make more apparent the law of growth and explain somewhat its cause. Beginning, then, with the pith, the structure in no way differs from normal dicotyledons. The cells are hexagonal and arranged in longitudinal rows The faces are approximately equal and finely pitted. The annual growth produces little displacement in the cells—at least no radical distortion. Numerous resin canals traverse the pith. These passages seem due to absorption of the contiguous cell walls, their length varying from a single cell to an indefinite number. The products of assimilation largely disappear by the end of the second year, though in older stems the pith sometimes appears heterogeneous. The pith finally becomes dark colored, partly from the infiltration of dyes from the duramen, but largely from degradation of tissue. At the periphery of the pith the cells grow smaller, thicker, and become elongated longitudinally, forming a well-marked medullary sheath. Projecting into this sheath appear numerous bundles of tracheids, the nucleus of the fibro-vascular bundles; a radial section through one of these bundles often showing from ten to fourteen of these small, delicate-walled vessels, with right-hand spirals rising in exceptionally regular and easy ascent. These tracheids appear rarely in the wood. They are at once recognized by their small size (12 μ, with a length of 150 μ), and by the fact that the septa always join the lateral walls at right angles.

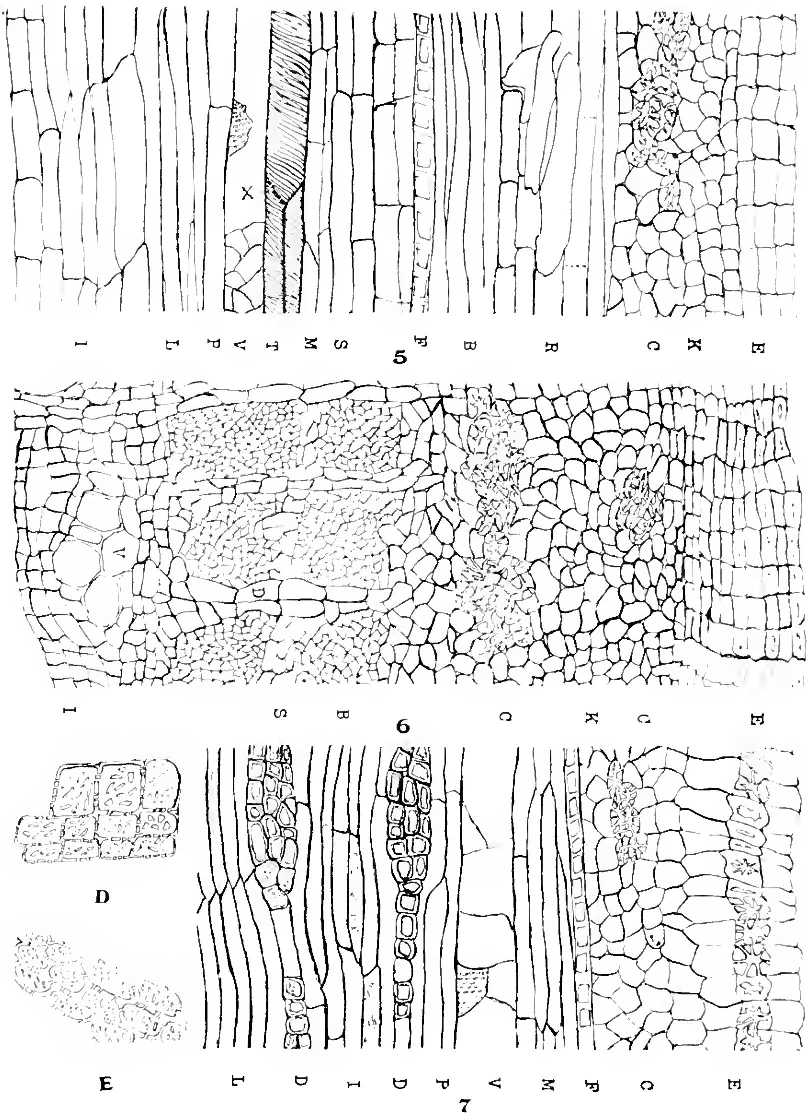
In discussing the elements of the xylem Sanio's classification will be followed. Though somewhat empirical, it furnishes a nomenclature more readily followed and understood than De Bary's or Sachs'. The tissue presents the forms found in many dicotyledonous woods—pitted vessels, spiral tracheids, libriform tissue, and bundle parenchyma (Figs. 5, 6, 7, and 8). These drawings, while *ad naturam delineatæ*, are intended simply to illustrate the characteristic features of the stem, all repetition of the same tissue and anatomical detail being omitted for clearness. The cambium tissue indicated at M is composed of lenticular cells perhaps more regular than here represented, being distorted somewhat in cutting. The differentiation of the cambium seems to follow no law. Bundles of the various elements are found irregularly associated. Usually arrayed in radial groups in the annual growth, they rarely present the same combination of

bundles for a series of years. During the first and second years the libriform tissue composes the bulk of the fundamental mass; in the succeeding annual zones it diminishes and may nearly disappear, being replaced by tracheids and vessels. The spiral tracheids figured at T are perhaps the most abundant tissue in the plant. Retaining their original cambium form, they illustrate especially well the transition from tracheid to vessel. If they exist as vessels their irregular course indicates at once where the septa were, as at X. As noted above, they differ from the spiral tracheids of the medullary sheath in their large and thickened walls, while the spirals often branch and the vessels become pitted (Fig. 9). No measurements will be given when the individual element is figured, the illustrations being designed to represent the average size of the cells. The pitted vessels, a small one of which is figured at V, are the most noticeable of the individual elements, being easily seen with the eye, and usually forming, after the sixth year, the bulk of the wood. They have much the same arrangement as in the *Quercus rubra*, the concentric circles seemingly confined to the autumn wood and figuring sparingly in the denser portions. The size of the ducts varies; comparatively small in the first zone, they increase annually and reach their maximum growth in from eight to ten years, often having a diameter of from 300 to 400 μ. The walls are much pitted with discoid markings. Fig. 10 represents a vessel separated by Schultze's fluid and viewed from without. The halos seem to be oval, arranged in rows, and alternating in the rows with one another. The canals are narrow slits, usually extending quite across the disc, and are partially concealed by the thickening membrane of the vessel. Tyloses is the rule with these vessels. The walls of the intruded parenchyma often become much thickened and pitted. The frequency is probably due to the fact that parenchyma usually borders these vessels, and the numerous slits afford it an easy ingress. These large and numerous tubes serve important mechanical ends in giving lightness and strength to the plant. A rough measurement of a cross-section places the area of the tubes as one-third that of the plant.

The wood parenchyma shows at P. In the variation of its dimensions and form it well exemplifies its name—*parenkeo*. The cells are irregularly pitted when contiguous to vessels or medul-

lary rays, and show a slight tendency to border pits when adjoining elements so marked. At I another very common form is shown. These latter cells would correspond to Sanio's intermediate tissue, in that they are libriform, contain food, and have all the characteristics of parenchyma; but in no case could oblique, slit-like markings be found. The libriform tissue, L, affords excellent examples of sclerenchyma. The cells appear stratified, showing a lignified outer wall, a thicker middle layer, and a homogeneous gelatinous inner layer (Fig. 11). The fibres often appear filled with the granular residue of the cell contents. In no case examined did they show striation or pitting. In the first year their growth appears very regular, but thereafter the ends extend themselves at sharp angles radially and tangentially. Thus the wood offers much resistance to splitting along any plane and gives great toughness to the vine.

The medullary rays extend in uni- or multi-seriate radial rows through the wood, the wider bands extending to the pith, while narrow ones appear between, formed each succeeding year as the dilatation of the stem continues. In tangential section their mode of origin from the cambium cell is evident. Considering now the phloem, it will be seen to be composed of bundles of sclerenchyma alternating with rows of parenchyma and sieve tubes. The regularity of this arrangement is often interrupted by the unequal growth of the parenchyma and the dilatation of the medullary ray. The sclerenchyma, B, resembles closely the fibres of the xylem. They exceed it, however, in length, but not in thickness (Fig. 13). The outer layer is less lignified than that of the wood, while the cartilaginous layer is greatly developed, often filling irregularly the entire lumen. Apparently there is no middle lamina (Fig. 14). Scattered through the sclerenchyma are fibres containing crystals. These septate cells were not without occurrence in the wood, especially in the older zone. In the bast they appear the first year and become at once its most pronounced feature. These crystal-bearing fibres seem to arise directly from the cambium, and have the general form of the bast. After the formation of the crystals each is separated by transverse divisions of the fibre. From twenty to thirty of these crystals appear in a fibre, each chamber being nicely proportioned to the size of the crystal. The fibres are not lignified,



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the walls remaining exceedingly delicate and transparent. Crystals appear in this delicate cellulose sack, embedded in a gelatinous medium which completely fills the chamber. About the crystal is a film which on treatment with iodine shows the reaction of cellulose (Fig. 15). The crystals belong to the monoclinic system, though the corners are often blunted and irregular forms result (Fig. 16). Crystals also appear irregularly scattered through the parenchyma. With the sclerenchyma alternates the soft bast, S. With the pressure of growth these cells are much distorted, and the delicate sieve tubes are so much compressed as to lose all trace of structure and perhaps entirely disappear. These tubes, in the cases where examination is possible, appear in the parenchyma adjoining the liber fibres, and thus correspond to the annual zones. Their lateral walls seem to be destitute of plates and the cribrose septa are nearly horizontal. They greatly exceed the parenchyma in length, but have about the same transverse measurements. These bundles of parenchyma and sclerenchyma correspond closely and, I believe, exactly with the annual zones of the wood; the outer ones being compact, with an excess of fibre, while the inner bundles of the phloem are generally characterized by an absence of fibre and the soft bast is multiplied to several layers, giving a loose structure. This development presents a striking parallel to the dense heart growth of the xylem and its later light structure. A marked characteristic of the phloem is the presence of resin receptacles. These are arranged in concentric circles following the parenchyma in its growth, but never appearing in the medullary ray. As viewed in cross-section they occupy from one to several cells and give a banded structure to the bast. The resin has the appearance of gamboge. It is an exceedingly inert mass, little affected by strong acids, and slowly dissolves in

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Explanation of Plate 34.

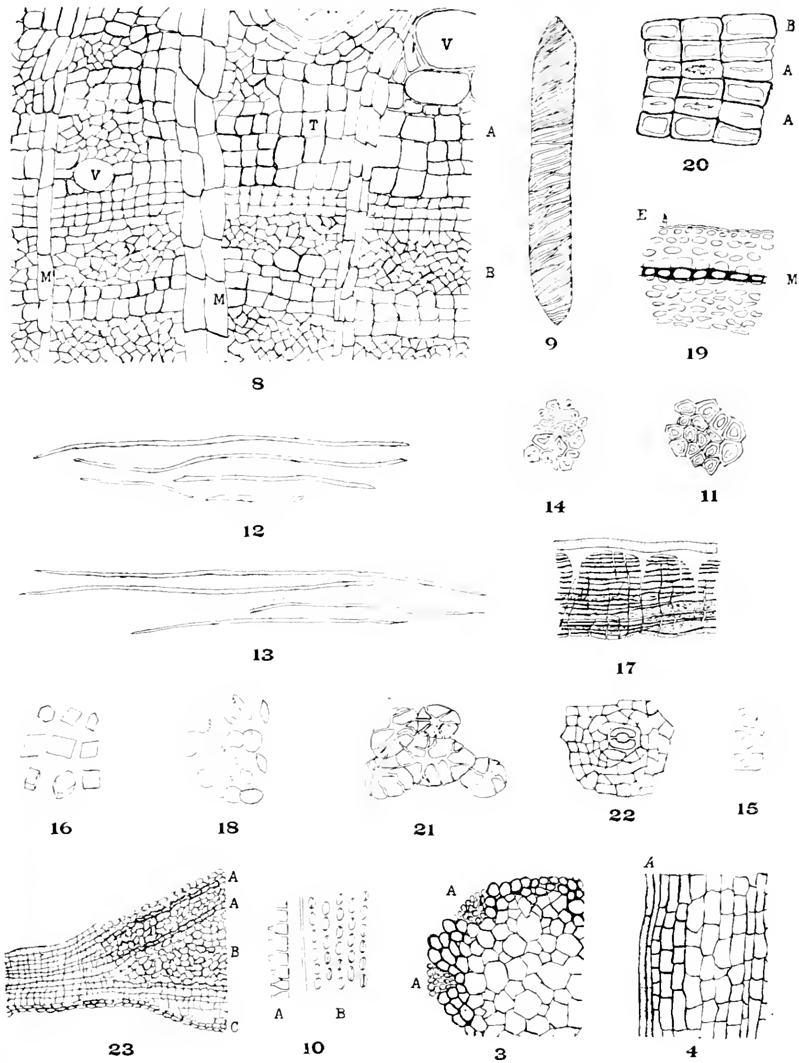
FIG. 5. Cross-section of stem. E, cork; K, parenchyma of periblem; C, cortical sheath; R, resin sack; B, bast fibre; F, crystal fibre; S, parenchyma of the bast; M, cambium tissue; T, a portion of three tracheids, showing at X an absorbed septum; V, trachea with tyloses, and a portion of its pitted wall; P and I, forms of wood parenchyma; L, liber fibre. × 500.—FIG. 6. Cross-section of stem lettered as in Fig. 5. D, medullary ray. × 300.—FIG. 7. Tangential section lettered as in Fig. 5, showing a layer of much thickened cork cells with pits. × 500.—FIGS. D and E. Radial and cross-sections of medullary ray, showing pitted walls. × 500.

Schultze's solution, losing its orange color and disappearing as an amber fluid. It is not improbable that this gum has the medicinal properties of gamboge, as Ottow found a poisonous glucoside in the bark of the *Wistaria*. Mention is not made of the properties of this poison, and it may have no connection with the resin, which does not occur in the bark. The latter term, however, may have been loosely used to include the inner cortex. The origin of these cells is lysigenetic. In the young bast and pith single cells of parenchyma are found filled with the resin; but with growth, either through rupture or dissolution of contiguous walls, the resin spreads, forming irregular branching passages. In the pith the resin slowly disappears before the period of degradation begins, but remains a constant feature of the phloem. The dilatation of the bast becomes very noticeable with the advance of age, forming the triangular white spots of the cortex (Fig. 17). This enlargement is brought about largely by the medullary rays, and usually by the multi-seriate ones. These broaden as they are pushed out by the successive annual zones, and by radial bipartition of the individual cells the original size of the cell is approximately maintained. These huge wedge-shaped masses of parenchyma often constitute the larger part of the bast, and so intermingle with the parenchyma of the outer cortical zone as to leave no line of demarkation between them.

Considering now the periblem, it is seen to consist entirely of parenchyma. The cells are filled with plastids containing chlorophyll, protein matter, and starch granules. These plastids are circular or lenticular in form, often showing starch embedding in or adhering to their surfaces. Fig. 18 illustrates the forms of plastids and starch granules found in the plant. The first change in this external cortical zone is the formation of the phellogenetic meristem. This takes place in the external layer of cells during the first year (Fig. 19). The development at first is entirely centripetal. Of the two cells formed by the first division, the outer one eventually becomes cork, while the inner one continues to grow and again divides, the inner one ever remaining active. But after the fourth or fifth year the development changes and becomes reciprocal. Now the inner of the cells formed by the division of the mother cell is no longer

meristematic, but becomes the first layer of the phelloderm. With the next division of the mother cell the outer cell is added to the cork, and, thus alternating, the successive zones are formed until about eight layers of phelloderm appear, when the growth once more becomes centripetal and so continues. In the younger stems a layer of cork is added each year. This appears to continue through life, for in the periderms of older stems the layers of cork so closely correspond to the annual zones that the loss of bark would easily explain the deficit. Thus the plant seems to be exceptionally regular in the formation of all its parts. The cork cells are tabular, appearing at first with delicate walls filled with sap (Fig. 20). If complete suberification of the walls results the cell contents remain as a brown, resinous mass, filling the cell. Sanio holds that air never appears in those cells which contain this residue of cell life. But cases are not wanting in which the contents seem to have drawn away from the walls, leaving an air cavity. This separation may be due to the disturbance of the cell either from chemical reaction or cutting. In many cells the cutinization is slight, in which case the inner lamina grows to the exclusion of nearly the entire lumen and becomes much furrowed by canals (E). It is worthy of note that these thickened and brown-colored cells usually alternate, giving a marked stratified appearance to the cork. The walls are transparent, even in the oldest cells, readily showing through the green of the phelloderm. They adhere strongly by their tangential walls, and when the pressure of growth finally severs them they curl back from the break, causing the scale-like appearance of the bark. Contemporaneous with the cork-meristem appears the first trace of the cortical sheath. Certain cells of the parenchyma adjoining or near the bast begin to thicken, and eventually become short-celled sclerenchyma, the lumen being nearly excluded and the pit canals much branched (Fig. 21). A zone more or less interrupted is formed, sharply separating the plerom and the periblem. Secondary bundles often arise outside the primary groups. This element is a very characteristic feature of the outer cortex, and affords exceptionally good material for the study of the origin and the development of sclerenchyma. The dilatation of the fundamental mass of the periblem keeps pace with the growth of the stem. In so doing there is a loss in

the thickness of the cell wall until these cells resemble perfectly those of the parenchyma of the phloem. In case of the commingling of the elements in this way groups of cells are moved from the cortical sheath, and in the phloem occasionally they undergo sclerosis. In the dermatogen is found but a single uniseriate zone. Growth continues apparently during the first year only, when life is cut off by the completion of the first layer of cork. Many of the cells are prolonged into hair-like trichomes, which probably assist the stoma in supplying the plant with air. No intercellular spaces occur save where stomata are formed. The cells are nearly rectangular, their superficial walls being much thickened and completely cutinized. They contain colorless granules and sap, starch however being found in the guard cells of the stoma (Fig. 22). With the formation of the cork a change occurs in those cells below the stoma in or near the meristem. As the cork is formed these cells exceed the growth of the periderm, and thus is formed a double convex swelling which pushes up the stoma long before death ensues (Fig. 23). At the phelloderm the cells are regularly arranged in rows containing a few granules and filled with a colorless sap. Outside of these are the complementary cells, with corners more or less rounded, and in structure similar to the cork. As in the cork, some are filled with the dried remains of cell life, but, being irregularly placed among the transparent cells, they present a mottled rather than a banded structure. This mass of loose complementary tissue is held together by layers of flat cells which alternate with them. These tabular cells adhere strongly by their radial walls, but, owing to their irregular tangential surfaces, they do not interfere with the access of air to the phelloderm. These cortical pores increase with the dilatation of the periderm, attaining in transverse diameter a length of five or six millimetres. The lenticles of the older stems are abundant and apparently exceed the stoma of the younger growths, and it seems not improbable that they are often formed under the trichomes which thickly beset the epidermis. In looking over the literature on the *Wistaria*, as noted in the *Botanischer Jahresbericht*, I find only incidental references made to it, as already noted. Both De Bary and Sachs, in their "Handbook of Physiological Botany," relying largely on the examinations of Eichler, Crüger, and Müller, place the origin



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of the successive rings of thickening in the older zones of the secondary bast. From examination of many sections taken from stems varying in age from four to twenty-five years, it seems impossible that the conclusions of the authors mentioned can be correct. The law may be true for the lians, with which they chiefly worked, and it is possible that the *Wistaria*, under different conditions of climate and soil, may conform to the above law. The cortical sheath of the *Wistaria* gives an unmistakable landmark by which to locate growth. This is always near the periblem and plerom boundary. No amount of it is found in any other place. If De Bary's position were true this sheath could never appear in the phloem that has been cut off externally by wood. It would ever be pushed out with the periblem by the new growth. But not a section of the interstratified phloem has been examined that does not reveal the cortical sheath on the periphery of the bast. It may be advanced that with the formation of the new cambium dilatation of the adjoining parenchyma and sclerosis follow. In this case the process could easily be noted, and, secondly, the dilatation would present features distinct from that manifest in stems where growth is yet normal. As a matter of fact, the structure of the included bast zones differs in no respect from that of the regular growth. The same widening of the medullary ray, and the completed sclerosis, etc., are always present. Again, in sections taken from the angles formed by the commingling of two bast zones, the sclerosis is seen to curve

Explanation of Plate 35.

FIG. 3. Cross-section of pith, showing fibro-vascular bundle, A, in the medullary sheath. × 200.—FIG. 4. Radial section of pith. A, spiral tracheids. × 200.—FIG. 8. Cross-section of xylem, showing A, autumn growth, and B, denser wood. × 500.—FIG. 9. Tracheid with anastomosing spirals. × 500.—FIG. 10. A, longitudinal section of tracheæ, showing forms of pits and canals; B, transverse view, showing the thickening portion encroaching upon the slit-like canals. × 500.—FIG. 11. Cross-section of liber fibres, showing stratification. × 500.—FIG. 12. Liber fibres separated by maceration. × 66.—FIG. 13. Bast fibres separated by maceration. × 66.—FIG. 14. Bast fibres, cross-section showing two layers. × 500.—FIG. 15. Three sacks of the crystal fibre swollen by maceration. × 500.—FIG. 16. Crystal forms. × 500.—FIG. 17. Cross-section of inner and outer cortex, showing the dilatation of the medullary ray. The heavy horizontal lines and the dotted spaces represent the relative amounts of parenchyma in the bast. × 12.—FIG. 18. Plastids and starch granules. × 500.—FIG. 19. Cross-section of stem, showing the cork meristem in the third layer of cells, and the epidermis with trichome, E. × 300.—FIG. 20. Cross-section of cork cells. A, A, the much-thickened cells; B, those completely suberized. × 500.—FIG. 21. Short sclerenchyma. × 500.—FIG. 22. Stoma of stem. × 300.—FIG. 23. Lenticle. A, A, tabular cells radially joined to retain in place the loose cells; C, phelloderm. × 200.

around from the outer bast in a clearly marked line to the outer periphery of the included bast. But one explanation can account for this, namely, that the new zone of growth arises in the periblem near the cortical sheath. Here, moreover, are all the elements necessary for growth—a living parenchyma rich in chlorophyll, starch, and protein matter. Only in a single stem was this growth seen to be in process. In this case the cambium seems to have risen on a line with the cortical sheath, for the wood fibres were interrupted by the bundles of sclerenchyma. This may be the place of new growth, since in removing the inner cortex from the wood the line of separation is always dentate, which outline the sclerotic bundles crowding into the wood tissue would exactly produce. It is not always apparent, however, that the dentation is due to this mode of development. The cause of the anomalous growth is doubtless due to pressure. As the annual zones are pushed out greater and greater resistance is offered to radial extension by the bast. The sinuous course, in the older stems, of the medullary ray would be indicative of this, but it is to be noted that the irregularity is almost entirely confined to the corrugated, gnarled stems and therefore is in great measure due to torsion. The radial distortion of the parenchyma and the collapse of the sieve tubes indicate more strongly the pressure of growth. Finally, as regards the fact that the secondary growths are less than those of the primary, it may be held that the plant reaches its maturity at about the twelfth year. Now the potential of the plant life is lower, new elements are added with less vigor, and consequently it can force back the bast for a shorter period.

Reviewing the elements of the stem, one cannot fail to be impressed with the wonderful regularity, economy, and fitness manifested in the arrangement of the tissue. The xylem, phloem, and periblem each receives its proportional annual increase, developing all its parts with a precision truly wonderful. The tough strands of the sclerenchyma were needed at first to give a strong rope of support to the vine with its heavy foliage ; but with the advance of age the complement of this was needed, lightness as well as increased facilities for the transmission of food. Now appear the larger elements—the tracheæ, hollow cylinders of support, made more light by their sculptured walls, while the tracheids with their thickened walls afford a

roadway for the rapid transmission of food. From an eighteen-year-old stem a quarter-section was taken, so as to secure all the elements in their relative proportion. From this the specific gravity was found to be only two and a half times that of cork. Thus at once is secured a stem of great strength and unusual lightness. But truly the most wonderful element is the bast, so fine that J. J. Rein, in a paper on the textile plants of Japan, credits the Japanese with attempting its manufacture into linen. This seems very feasible, for the elements have a diameter of 12 μ and reach a length of 230 μ, in appearance and measurements corresponding closely with *Linum usitatissimum* (Fig. 13). In their strength they exceed all the other elements of the stem. From some rather unsatisfactory tests of the sustaining power of the bast it was found that a piece two millimetres wide and one millimetre thick would sustain a weight of twenty-two and seventy-three hundredths kilos, more than one-fifth of the sustaining strength of soft iron. Here again the adaptability of the plant to its mode of life is manifest. The strength of the bast cylinder alone would doubtless be sufficient to meet all strains brought to bear upon it; but considering the older stems, often surrounded by several concentric cylinders, the strongest form of structure possible, the utility of the arrangement to the plant is obvious. At the low estimate given above, an old stem before me showing three bast zones would have a sustaining power of over half a ton. There now remains for consideration the life of the plant—by no means its least interesting feature. For in the adaptation of its growth to meet the strain laid upon it, there arose in the bast such a barrier to development that the life of the plant must cease or the restraint be overcome. And so, to secure to itself at once its element of strength and life, the barrier wall is left unbroken and life begins anew beyond the bast and without restraint.

PROCEEDINGS.

Meeting of February 19th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Sixty persons present.

Prof. Samuel Lockwood, Ph.D., addressed the Society on "The Blood after Electrocution." This address referred especially to the appearances of the corpuscles of the blood of Kemmler, the first victim in the State of New York of the infliction of the death penalty by means of the electric current.

Dr. Lockwood maintained that the condition of the red corpuscles of the blood, taken from the head of the victim in the direct path of the current five minutes after electrocution, shows the effect of the dreadful shock. "Here is an exhibit of an astonishing catastrophe. In no instance has a single corpuscle escaped damage. All are reduced fully one-third in size. Many of them look as if they were smashed. From some the protoplasm exudes like the pulp from a crushed grape. Many are reduced to mere granules, and distortion is general."

The address was illustrated by lantern projections of photomicrographs of blood corpuscles from various animals, from normal human blood, and from Kemmler's blood, and also by preparations under microscopes as indicated below.

OBJECTS EXHIBITED.

1. Blood of Frog.
2. Blood of Alligator.
3. Blood of Pigeon.
4. Blood of Dog.
5. Normal human blood.
6. Kemmler's blood, from the thigh.
7. Kemmler's blood, from the head.

All by Samuel Lockwood.

Meeting of March 4th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fifteen persons present.

OBJECTS EXHIBITED.

1. *Navicula trinodis*, from Ashbourne, Pa.

2. *Coscinodiscus excavatus*, from artesian well at Beach Haven, N. J.

3. *Triceratium* (new species), from the same.

Exhibits 1–3 prepared by Dr. C. Henry Kain and exhibited by E. A. Schultze.

4. Wood fibre from coal, Deer Creek, Walker Co., Ala.

5. Sporangia from the same.

6. Macrospores from shale, Ontario, Canada.

Exhibits 4–6 prepared by K. M. Cunningham and exhibited by Geo. E. Ashby.

MEETING OF MARCH 18TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fourteen persons present.

OBJECTS EXHIBITED.

1. Serial sections of the fish, *Atherina* sp. (Silversides), through the gills: by L. Riederer.

2. Serial sections of the same, through the head: by L. Riederer.

3. Serial sections of the same, through the eye: by L. Riederer.

4. Malachite, from Arizona: by Geo. E. Ashby.

5. Brucite, from Hoboken, N. J.: by Geo. E. Ashby.

6. Sea-sand, mounted movable in fluid: by J. D. Hyatt.

7. Fresh-water Diatoms, from Montgomery, Ala., prepared in monobromide by Dr. Ward, of Poughkeepsie: by J. D. Hyatt.

8. Pigeon-post film, used in the siege of Paris: by J. D. Hyatt.

9. Twenty-five Photomicrographs of various preparations: by Frank D. Skeel.

MEETING OF APRIL 1ST, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Forty persons present.

Dr. Carl Heitzmann addressed the Society on "Fallacy of the

Cell-Theory." This address was illustrated by microscopical preparations as stated below.

OBJECTS EXHIBITED.

1. Cornea of Cat, with basis substance stained with chloride of gold showing reticulum.

2. Cornea of Cat, stained with nitrate of silver.

3. Section of human tooth with silver amalgam, showing reticulum in the dentine.

4. Dentine of human tooth, showing effect of amalgam.

All by DR. CARL HEITZMANN.

MEETING OF APRIL 15TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Fifteen persons present.

OBJECTS EXHIBITED.

1. Aventurine Feldspar (Sunstone), from Sussex Co., N. J.: by JAMES WALKER.

2. Section of the same by polarized light: by JAMES WALKER.

3. *Megalotrocha.*—Rotifer colony—illustrating a convenient method of transportation and exhibition: by JAMES WALKER.

Mr. Walker explained the ingenious and convenient method of handling the colony of Rotifers exhibited by him. A microscopical cover glass is attached to one end of a thread by means of a minute piece of wax. The cover glass is suspended in the water of an aquarium. The thread passes over the edge of the aquarium, and at the end, hanging outside, a balancing weight, consisting of a small shot or any other convenient minute object, retains the cover glass in any desired position in the water. When a colony has attached itself to the cover glass, glass and colony can be transported by transferring them uninjured to a bottle of water, and they can be conveniently retained in any position for examination on the stage of the microscope by transferring them from the bottle to a stage tank.

Mr. Walker also described the piece of apparatus, constructed by himself, for revolving the polarizing prism on the microscope. A small shaft is attached to the substage, carrying at one end a

milled head, slightly projecting beyond the microscope stage, and having at the other end a pinion engaging in a crown-wheel, fastened to the tube containing the prism.

ANNUAL EXHIBITION, APRIL 22D, 1892.

The Thirteenth Annual Exhibition of the Society was held at the American Museum of Natural History, Central Park, New York City, on the evening of April 22d, 1892.

The objects exhibited, as noted in the programme below, were displayed in the large hall of the first floor of the Museum. During the evening there were three exhibitions of thirty minutes each in the spacious Lecture Room adjoining, as follows: At 8 clock—Exhibition of Lantern Slides of Photomicrographs, by E. G. LOVE. At 9 o'clock—Exhibition of Lantern Slides of Diatoms, by C. F. COX. At 10 o'clock—Exhibition of Microscopic Objects with polarized light by E. C. BOLLES.

PROGRAMME.

1. Old Microscopes and Accessories (Alcove No. 1). Loaned by C. F. COX, J. L. ZABRISKIE, WM. WALES, F. D. SKEEL, L. SCHÖNEY, and the American Museum of Natural History: by WM. WALES.

2. Method of Grinding and Mounting Lenses for the Microscope (Alcove No. 1): by WM. WALES.

3. Transverse Section of the Pad of a Cat's Foot, showing "touch" corpuscles: by GEO. E. ASHBY.

4. Saws of Rose Saw-fly: by GEO. E. ASHBY.

5. Transverse Section of the Stem of Cycas revoluta: by GEO. E. ASHBY.

6. Revolving Stage with eleven objects: by THOS. TAYLOR.

7. Sponge Spicules, Barbadoes: by E. J. WRIGHT.

8. Crystallized Zinc Oxide: by FREDERICK KATO.

9. Hydromagnesite, Hoboken, N. J.: by J. W. FRECKELTON.

10. Sunstone, a variety of Feldspar, Sussex County, N. J.: by A. H. EHRMAN.

11. Arachnoidiscus in situ on Seaweed: by F. E. BLOODGOOD.

12. Microphotograph, The Madonna, Raphael: by A. WOODWARD.

13. Crystals of Chlorate of Potash, with polarized light: by A. WOODWARD.

14. Scales of Morpho Butterfly from Brazil: by WM. BEUTENMÜLLER.

15. Section of Cornstalk: by WM. BEUTENMÜLLER.

16. Vinegar Eels, living: by ALFRED BEUTENMÜLLER.

17. The Oyster, examined microscopically and otherwise (Alcove No. 2): by GEO. W. KOSMAK.

18. Bouquet made from Butterfly Scales: by E. A. SCHULTZE.

19. Arranged Diatoms from Santa Monica, Cal.: by E. A. SCHULTZE.

20. Stellate Hairs on Leaf of Deutzia scabra, with polarized light: by J. L. WALL.

21. Pollen Grains of Lavatera in situ: by H. C. BENNETT.

22. The Diamond Beetle, *Entimus imperialis*: by M. H. EISNER.

23. Silicious Cuticle of Equisetum, with polarized light: by M. H. EISNER.

24. Case for Microscope and Accessories, made of mother-of-pearl: by M. H. EISNER.

25. Cutting, Staining, and Mounting of Serial Sections by the Paraffin Process (Alcove No. 3): by L. RIEDERER.

26. Section of the Abdomen of a Dragon-fly: by L. RIEDERER.

27. Transverse Sections of the Tongue of a Butterfly, *Colias Philodice*: by L. RIEDERER.

28. "Sea Spider," *Phoxichilidium*: by L. RIEDERER.

29. Chromatophores or Pigment Cells in skin of common Shrimp, *Crangon vulgare*: by HEINRICH RIES.

30. Red Earth-mite, *Trombidium*: by WM. HUCKEL.

31. Yellow Ochre, pseudomorph after Siderite, New York City: by JAMES WALKER.

32. Sections of Dumortierite in Orthoclase, Oligoclase, Fibrolite, Serpentine, Scapolite, and Mica with inclusions, shown with automatic revolving stage and polariscope: by JAMES WALKER.

33. Specimens illustrating successive stages in Grinding and Mounting Rock Sections: by JAMES WALKER.

Microphotography (Alcove No. 4), Apparatus and Slides: by S. N. Ayres:

34. Bird's-eye View of the Columbian Exposition.
35. The Dream of Pharaoh's Wife.
36. Portrait of Child.
37. Foes or Friends.

38. Influenza Microbes: by L. Schöney.

39. Trichinæ Spiralis in Human Muscle: by J. A. Gottlieb.

40. Photomicrographs: by J. A. Gottlieb.

41. Cutting, Grinding, and Mounting of Rock Sections (Alcove No. 5): by J. D. Hyatt.

42. Section of Agate, with polarized light: by J. D. Hyatt.

43. Vibratile Cilia of Mussel, *Mytilus:* by J. D. Hyatt.

44. Circulation of Blood in a Frog's Foot: by J. D. Hyatt.

45. Porpita Linnæana, a Hydrozoan, allied to the Portuguese Man-of-war: by L. P. Gratacap.

46. Pond Life: by Thos. Craig.

47. Skin of Leptosynapta, showing Anchors and Plates: by W. C. Kerr.

48. Section of Scotch Coal, Stigmaria: by H. W. Calef.

49. Fern-leaf Crystals of Gold: by G. S. Woolman.

50. Head of Mosquito: by G. S. Woolman.

51. Human Blood on Holman's Slide: by F. H. Leggett.

52. Circulation in Nitella: by F. W. Devoe.

53. Circulation in Vallisneria: by F. W. Devoe.

54. Crystals obtained from the Blood of a Caterpillar, with polarized light: by Samuel Lockwood.

55. Native Crystallized Gold, Colorado. Slide mounted with removable cover glass: by A. H. Chester.

56–59. Pond Life, including the following forms recently discovered by the exhibitor: *Lagotia cæruleus*, *Urnatella Walkerii*, *Octocella libertas*, and *Cordylophora coronata* (Alcove No. 6): by Stephen Helm.

60. A Series of Drawings of the Lower Forms of Animal Life (Alcove No. 6): by Stephen Helm.

61. Head of a Tape Worm: by Miss M. V. Worstell.

62. Luxullianite, with polarized light: by Miss M. V. Worstell.

63. Hydroid, Obelia, showing Polypites, Gonophore, and attached Diatoms: by G. S. Stanton.

64. Iodo-Sulphate of Quinine, with polarized light: by GEO. M. HOPKINS.

65. Autograph of the Electric Spark: by GEO. M. HOPKINS.

66. Arranged Group of Diatoms, illuminated by Parabola: by C. F. COX.

67. Crystals of Quinidine, with polarized light: by C. F. COX.

68. Trichomes and Transverse Section of the Leaf of the Long Moss, *Tillandsia usneoides* L., from Florida, with polarized light: by J. L. ZABRISKIE.

69. A new Microscope Lamp: by J. L. ZABRISKIE.

70. Photomicrographic Apparatus with Photomicrographs (Alcove No. 7): by E. G. LOVE.

71. Palate of Whelk, *Buccinum undatum*: by E. G. LOVE.

72. Section of the Ovary of Indian Pipe, *Monotropa uniflora*: by E. G. LOVE.

73. Section of Echinus Spine, *Echinometra lucunter*, with polarized light: by E. G. LOVE.

74. Finest Manchester Muslin: by E. G. LOVE.

75. Human Hair from Beard: by E. G. LOVE.

76. Suction Cup from Arm of Devil-fish, *Architeuthis princeps*: by WM. E. DAMON:

77. Skin of Sole: by W. H. MEAD.

78. The Ruby: by GEO. F. KUNZ.

Etchings of Steel, showing Structure (Alcove No. 8): prepared by P. H. DUDLEY and exhibited for him by THOS. B. BRIGGS:

79. Exterior columnar Structure of a .50 per cent carbon Bessemer Rail Ingot.

80. A .26 per cent carbon Bessemer Rail Head, which is so coarse that it wears rapidly under heavy traffic.

81. A good low-carbon Rail, the carbon being nearly all combined.

82. Dense Structure of a .60 per cent carbon Rail.

83. A 3 per cent nickel Armor-plate Ingot.

84. Ordnance .40 per cent carbon steel, after hydraulic forging.

85. Photomicrographs showing structure of steel.

86. Section of Retina of Human Eye, showing Rods and Cones: by F. D. SKEEL.

87. Section of Human Eye, showing cancerous growth (*Melano-sarcoma*): by F. D. SKEEL.

88. Cheese Mites, *Acarus domesticus:* by W. D. MACDONALD.

89. A Series of Photomicrographs, made by the late DR. J. J. WOODWARD (Alcove No. 9): by C. F. COX and E. G. LOVE.

90. Polycystina, Barbadoes: by H. F. CROSBY.

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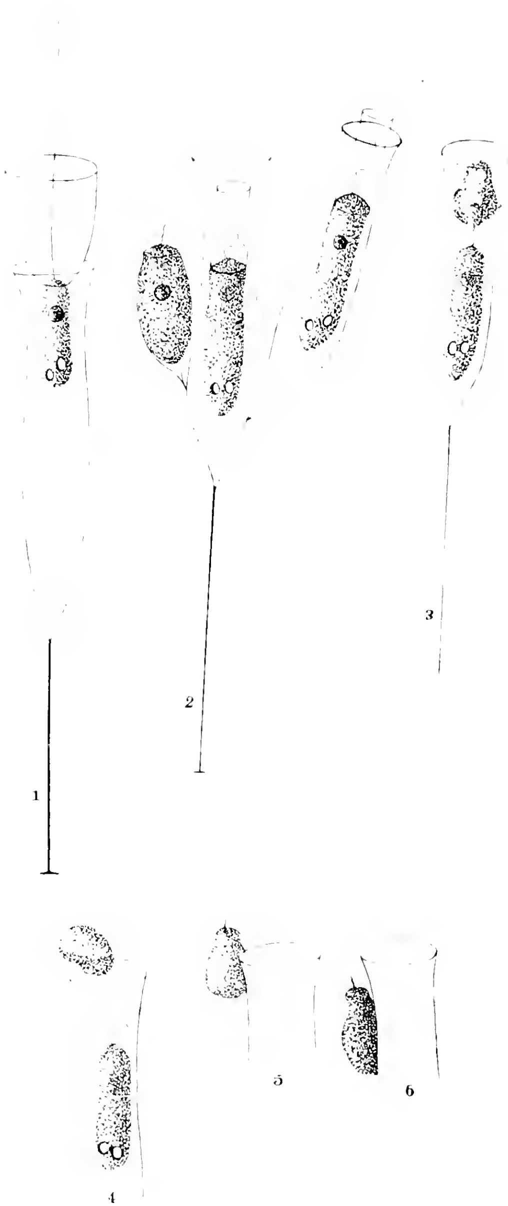

SALPINGŒCA GRACILIS.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. VIII. OCTOBER, 1892. No. 4.

A NOTE ON A VARIETY OF SALPINGŒCA GRACILIS J.-CLK.

BY ALFRED C. STOKES, M.D.,

Corresponding Member of the New-York Microscopical Society.

(*Presented June 17th*, 1892.)

In October of last year (1891) I received, through the kindness of Mr. Stephen Helm, a gathering made from the Morris and Essex Canal near Claremont, N. J. The collection was an exceedingly rich one, containing several microscopic animals which up to that time had not been seen by any human eye. These are in the care of my courteous correspondent, and have been by him referred to in a recent number of this JOURNAL. It is consequently not to these remarkable and remarkably interesting creatures that I wish now to refer, but to a minute member of the group of charming Infusoria classed together by systematists in the order Choano-Flagellata, or "the collared monads." These beautiful little creatures have long been particularly interesting to me, not only on account of their attractive and artistic forms, their unusual habits and characteristic structure, but because they are especially American Infusoria, although many have been found in Europe. They were originally discovered here

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Explanation of Plate 36.

FIG. 1—*Salpingœca gracilis* J.-Clk. Typical form.

FIG. 2—A small colony of the brackish-water variety, with two loricæ, and with an embryo recently escaped from the parent sheath and secreting its lorica.

FIG. 3—Embryo soon after separation from the parent.

FIGS. 4, 5, and 6—Embryos leaving the parent lorica to assume a position externally adherent.

by the late Professor H. James-Clark, who connected them in an intimate manner with the microscopic structure of the sponges. They have been studied by Stein, by Saville Kent, and by Butschli in Europe, but in this country, the land in which they were first found and in whose fresh and salt waters they are in profusion, microscopists have almost entirely neglected them; yet they are worthy of every attention. The explanation of this apparent neglect seems to lie in the small size of the infusorians, and in the consequent demand for high-power objectives in their study.

The twigs and other objects in the water from the Morris and Essex Canal sent me by my correspondent, were adorned with a great number, indeed with hundreds, of a species of *Salpingœca* so nearly resembling James-Clark's *Salpingœca gracilis* that I had no hesitation in identifying it as that form. But almost at once there entered two facts which gave me pause. First, the animalcule had a habit which has not thus far been recorded with *Salpingœca gracilis* nor with any other member of the class; or perhaps I should express it as a modification of a habit common to all, but a modification until now not recorded and presumably not observed. And second, the water, when allowed to evaporate in a watch glass, deposited crystals of common salt; it was brackish water, but without this accidental occurrence I should have called it sweet, although I was surprised to find many apparently salt-water Infusoria in it, and was at a loss to explain their presence. This adds another element of interest to the *Salpingœca* which, although undoubtedly *Salpingœca gracilis*, has been modified in habit, presumably by the condition of the water, without a corresponding change in the form of body or of lorica. It has assumed another and more complex condition, and seems to be in a transition stage between a salt-water variety of *Salpingœca gracilis* and a distinct species. The addition of a pedicle to each lorica, each of which except the founder of the colony is now sessile, would force it into a new species.

The common and abundant form of the *Salpingœca gracilis* is that shown in Plate 36, Fig. 1. It is a solitary animal, rarely being found in near proximity with its fellows of the same species. It may often be seen scattered singly along a thread of alga or of some similar object in fresh water, but it is usually averse to

company. In the brackish water sent me by Mr. Helm I have found this form standing beside the variety just referred to and shown in Fig. 2, where, from the retiring, solitary creature, it is becoming a social colony like so many others of its congeners.

Of course it is not possible to imagine the cause that induced the embryo of the original aspirant after colonial honors to cling to the lorica of the parent and there produce a lorica of its own; and what induced other embryos to follow suit is as obscure; but each lorica with its enclosed animalcule represents a mature and full-grown embryo which, for some reason unknown, had not wandered, as is the usual custom, to found a home at a distance. It will be noticed that the appearance of the imperfectly formed colony is sufficiently different from the original, fresh-water individual to set the investigator to thinking; and while it would scarcely in this condition be figured and described as a new species, yet it is not unreasonable to suppose that it is on its way to that end, and that at some time in the near future it will merit a place in at least a provisional, working list of species. In these transition forms the primary, original foot-stalk answers for a support to the entire community, as it will probably continue to do, but the individuals of the group will in time, and perhaps in not a remote time, learn that they can obtain a better and a more constant food supply by elongating a foot-stalk from the posterior extremity of each constituent member. The colony, now irregular and incomplete, will then be symmetrical and regular in contour, as all similar colonies prefer to be, and each member will have the same opportunity to get food as every other one. Each individual of all such colonies is really independent of all others in the community, and its food supply depends upon its individual efforts. To have one or more deprived of its necessary aliment would be to weaken it, and to weaken its offspring so that the embryos would degenerate rather than develop upward; it would undergo degeneration rather than evolutionary advance.

The embryo that discovered there were advantages to be obtained by clinging to the parent's lorica, and thus sparing itself the trouble and the exhaustion of secreting a foot-stalk of its own, seems to have transmitted, in even a very short time, the new habit to its embryo, and these imperfect colonies are there-

fore in process of formation. A habit which seems to have been so easily acquired, and especially a habit which must be so beneficial to the animal, is not going to be forgotten nor abandoned. Thus far there has been no tendency, in the hundred or more colonies which I have seen, to produce other than an irregular form in which the loricæ are attached to one another by what seems to be a haphazard arrangement, producing an unsymmetrical and ungraceful result. Yet in some of these larger colonies there is also visible what it needed but little acumen, in one familiar with the appearance and the habit of this infusorial class, to predict, adding still another feature of great interest to these special, intermediate forms. In some of these collections of irregularly adherent loricæ or one two of the constituent animals has actually secreted a minute, secondary pedicle by means of which it is attached to the supporting lorica, be that the parent sheath or that of a member of the cluster (see the lateral zooid in Fig. 2). Here is a variety within a variety, and, if the apparent desire to change continues, the secondary pedicle will become a permanent feature, and the point of adherence will also be changed from a point on another lorica to the top of the primary pedicle, and another species will have been formed, or at least a closely connecting, varietal link between the fresh-water *Salpingœca gracilis* and a salt-water representative which has not yet been found, probably because, with the exception of James-Clark, no microscopist in this country has paid the least attention to the Choana-Flagellata of salt water. The field is entirely unoccupied, and is at the disposal of any microscopist that is properly equipped with objectives and so situated that he has access to the ocean.

But this is not all. If it was it would be interesting and suggestive, at least to the writer; but there is more which is still more surprising to the student of these special Infusoria. The animal has actually made alterations in the mode of its reproduction, thus adapting its manner of increase to its new and improved manner of living. With all other members of this group of animals, the reproduction is by the transverse fission of the parent's body; the latter divides into two parts, the one remaining in the old lorica, the other swimming off to find a new location and there producing a new lorica. The free-swimming portion

dashes out of the parent sheath with great rapidity. It leaps out with indescribable activity and is gone like a flash. In appearance it is a simple *Monad*, having an ovate body and a long, anterior flagellum, the flagellum always being at the front. To all appearance it is a *Monad*, and, if its origin were not known, the observer would be excusable for so classifying it. The monadiform germ of the fresh-water *Salpingœca gracilis* is exceedingly active for a short time, when it settles down in some pleasant spot and develops a foot-stalk and a lorica like its parent's. But this brackish-water variety has here made a change. It reproduces itself by transverse fission, it is true, but its flagellum, instead of being at the frontal extremity, is at the opposite pole; and instead of being several times longer than the body bearing it, is shorter than half that body width. This is shown in Fig. 3, where the parent is retracted into the back part of the lorica, and the young, monadiform germ is in the front and apparently upside down. It remains in this position for a few moments, and then, with great deliberateness and slowness, glides up the inner wall of the lorica and gently over the edge (as shown in Figs. 4 and 5), when its stiff, motionless little flagellum gets in the proper position, because its owner then places itself right side up. Clinging closely to the parent's lorica, it slowly glides along the outer surface, as in Fig. 6, until it reaches an acceptable resting point, when it proceeds to secrete its lorica, as shown on the left-hand side of Fig. 2. Here, instead of the wild if uncertain and wavering dash for liberty as performed by the embryos of the ordinary forms of the fresh-water members of the group, the movements are exceedingly deliberate and slow, the change being a surprising one to the microscopist that has become familiar with the hurrying and skurrying of the ordinary embryo.

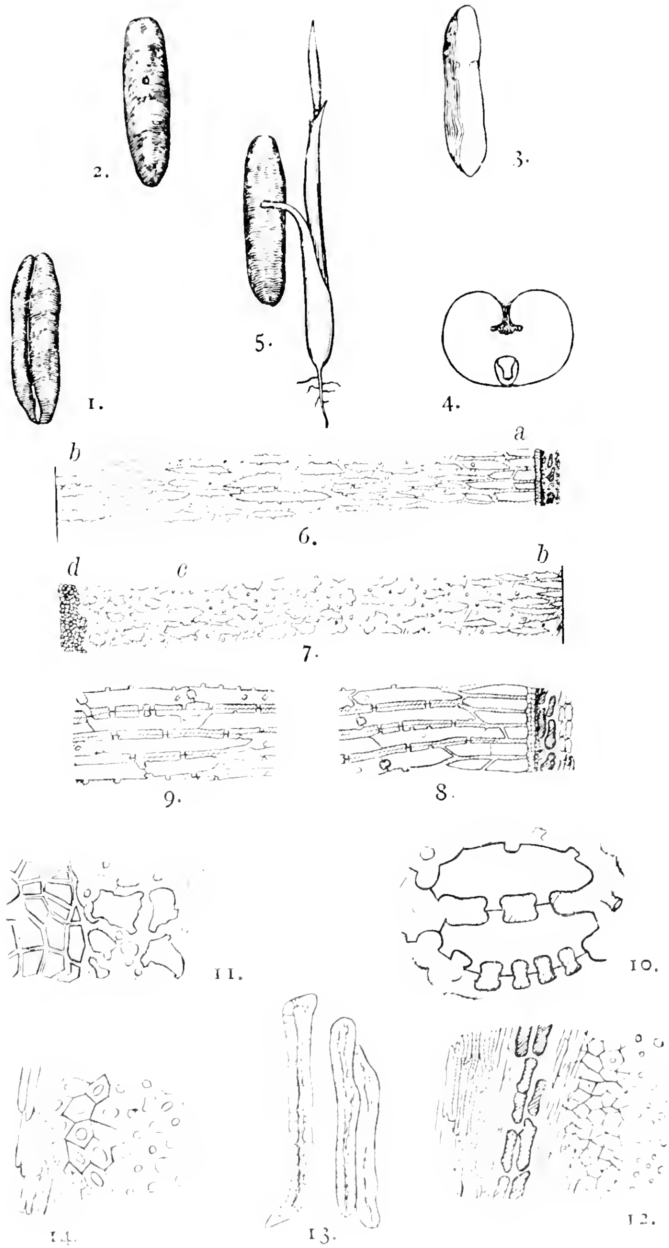
How these movements are effected I have not been able to learn. They are slow and continuous, but there is no apparent movement of the protoplasm, and no visible amœboid projections of the endoplasm. The movement also takes place as well when the animals are upside down as when they are in the right position, performed as well against gravity as in its direction. It is probable that the wave-like movements of the lower surface of the embryo needed to produce the onward progression are so

minute that they are concealed by the mass of protoplasm above, although this is almost entirely transparent.

These facts seem interesting and provocative of thought. That a little creature like this, whose protoplasmic body is only $\frac{1}{1125}$ inch in length, should deliberately change its habit of living alone and at a distance from its kindred, is interesting; but that it should permanently modify the actions of its embryo so as to bring about those altered conditions, is startling.

A recent writer lays it down as a broad and undisputed proposition that changes in form resulting in new species are not the result of slow modifications extending through countless ages, and which those that speculate on the changes induced by the visits of insects so warmly contend for. Changes, the author asserts, are by leaps and not by slow modification. There seems a greater energy at work at times than at others in producing change. It thus seems pleasant to imagine that, in finding this infusorian undergoing its changes into at least a distinct variety, one of these leaps might be actually in the process of taking place.

The irregular colonies which I have referred to are to be seen in many sizes, from a young cluster of two (the parent and the newly matured infusorian) to older clusters of a dozen or more members, some clinging to the body of the original or parent sheath, others adherent to the more recently formed lorica.



PHŒNIX DACTYLIFERA L.

NOTES ON THE STRUCTURE OF THE FRUIT-STONE OF THE DATE, PHŒNIX DACTYLIFERA L.

BY J. L. ZABRISKIE.

(*Read June 3d*, 1892.)

The sculpturing of cell walls, resulting from thickening deposits, always presents an interesting field of microscopic investigation in vegetable structure. The variety of form exhibited, the beauty of tracery and regularity of deposit, as seen in many spiral and annulated vessels, the surprising adaptations to the necessities of the organization, continually encourage examination. A striking example of this thickening of cell walls is afforded by the endosperm of the fruit-stone of the Date.

The stone is fusiform with irregularly rounded ends (Plate 37, Fig. 1). A thin, firm, uniformly light-brown outer coating covers all the surface, excepting that occupied by the deep longitudinal cleft, extending the entire length of one side of the stone, and filled with a dark-brown, soft, cellular structure. When the stem end of the fruit-stone is uppermost, at the lower end of the cleft will be found a little, hard, grooved, conical prominence, projecting downward and indicating the distal end of the fruit, opposite the stem. On the side directly opposite the cleft, and usually a little above the middle of the stone, may be noticed a small circular depression enclosing a hemispherical prominence and indicating the position of the embryo within (Fig 2). A longitudinal section of the entire stone through the cleft (Fig. 3) shows the position of the embryo, which is seated, entirely free excepting a slight detachment at its inner end, in a little ovoid cavity. A transverse section through the entire stone and through the embryo (Fig. 4) shows the inner lateral enlargements

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Explanation of Plate 37.

FIG. 1—Fruit-stone of the date, showing longitudinal cleft and conical prominence. FIG. 2—The same, showing the position of the embryo. FIG. 3—Longitudinal section, showing the embryo in its cavity. FIG. 4—Transverse section, showing the same. × 3. FIG. 5—The fruit-stone germinating. (Figs. 1, 2, 3, and 5 all natural size.) FIGS. 6 and 7—A continuous narrow band of the transverse section of the stone, from the seed coats *a* through *b* and *c* to the soft structure of the cleft at *d*. × 50. FIG. 8—A portion of the transverse section at *a*. × 100. FIG. 9—A portion of the same at *b*. × 100. FIG. 10—Two cells of the same at *c*. × 200. FIG. 11—A portion of the same at *d*. × 200. FIG. 12—Longitudinal-tangential section, showing outer seed coats on the left hand and beginnings of the spindle cells on the right hand. × 75. FIG. 13—Three cells from the same section with abundant capillary canals. × 200. FIG. 14—A portion of the middle of the same section. × 200.

of the cleft, filled with the brown cellular tissue. In germination the embryo issues from the little depression (Fig. 5), the root descends into the soil, the plumule rises with its successive leaves, but the extremity of the single seed leaf remains within the stone.

The entire mass of the stone, excepting the firm brown coating, the embryonal cavity, and the cellular structure of the cleft, is a remarkably uniform, bluish-white endosperm, without flaw or blemish, nearly as hard as bone. The cells of this endosperm are of various sizes and forms, but many of them are long spindles, and the "grain" of the entire inner structure, caused by the adjoining rows of cells, considering their longer diameters, always lies in the direction of radii, converging from the hard outer coat toward a longitudinal axis, lying within the cellular structure of the cleft. Therefore the sections must lie in the planes of these radii, or in planes perpendicular to the radii, to avoid the confusion resulting from cutting the cells obliquely.

All the sections exhibited are taken at the middle of the stone, slightly below the position of the embryo. The transverse section extends entirely across the solid substance of the endosperm from the hard outer coating to the soft tissue of the cleft. The longitudinal-radial section extends in the plane of one of the radii, running from the hard coat to the long axis. And the longitudinal-tangential section lies in a plane perpendicular to such radii. These last sections were obtained by shaving off the hard coat longitudinally for only a slight depth. Deeper cutting, of course, gradually approaches the position of a longitudinal-radial section.

In preparing the sections the stone was split open by the blow of a hammer on a knife blade, applied longitudinally and transversely, and the pieces were macerated for a few days in cold water, with one drop of carbolic acid solution to the ounce to prevent putrefaction, or in a moderately strong solution of caustic soda. Either process will soften the stone sufficiently for cutting, but the soda more rapidly disintegrates the layers of the outer brown coating, thus preventing the view of these cells in their natural position. The sections were cut free-hand with a razor. The necessarily varying thickness of such a section is very instructive. In the thicker portions of the section the relations of the cells to each other will be seen, where they lie in several layers; while the internal structure of the several cells will be

more clearly discerned where, at the edges, the section thins away almost infinitesimally. The sections were cleared of cell-contents by boiling in a dilute solution of caustic soda, stained with hæmatoxylin, and mounted in balsam.

Figs. 6 and 7 represent a continuous narrow strip of the transverse section, running from *a*, through *b* and *c*, to *d*—from the brown seed coats to the soft tissue of the cleft. The cells of the seed coats will be mentioned more conveniently under a consideration of the longitudinal-tangential section. Just within the seed coats at *a* is a structure of peculiar cells, bounding the entire circumference of the endosperm, which, from their form, may be termed palisade cells. They are uniformly thickened cells with smooth walls. They vary in length. Some of them are nearly cubical. But the majority of them are hexagonal prisms, with a nearly flat outer end, next the seed coats, and an obliquely truncated end, within, toward the endosperm.

Immediately succeeding these last lie the "spindle cells," slightly overlapping each other, and with their long diameters all directed toward the long axis of the stone. In the figures the clear spaces represent the interior of the cells, and the oblique shading represents the cut surface of the adjoining thickened cell walls. In a general view of the section, next after the striking appearance of the cell cavities, the attention is arrested by the appearance of an immense number of little circles irregularly scattered through the structure. These circles are the sections of the deep and remarkably uniform pores, extending from the interior of the cells, through the thickened cell walls, to the middle lamella between two adjoining cells. This explanation is easily demonstrated by a view of the uncleared cell contents in some of the thicker portions of the section. The cell contents take the stain more deeply than the cell walls, and occasionally, where a cell has not been cut open by the section, the soda treatment has failed to expel the contents, and these contents then form a distinct dark-colored cast of the cell cavity. This cast is somewhat cigar-shaped and studded with numerous prominent projections, like stout projecting nail heads. These nail heads are evidently the casts of the cell contents filling the pores. And the little circles abounding through the structure are the sections of these pores in various positions, now emptied of their contents.

The spindle cells extend within from the palisade cells at *a* (Figs. 6, 7), through more than one-half of the entire radius of the stone, for a short distance beyond the line *b*. Succeeding this another form of cells will be met. They are very irregular in outline, have the cell walls more thickened than any of the others. and are supplied with an immense number of pores extending in every direction. Although very variable, the majority of them are sub-globular, and hence they may be termed the globular cells. They are most prominent about the position *c* of Fig. 7. At last, at *d*, the structure filling the cleft is reached—a mass of brown, thick-walled, but soft polygonal cells.

Fig 8 is an enlarged view of a small portion of the transverse section, corresponding with *a* of Fig. 6. On the right are seen the sections of cells of the seed coats. Next these are the palisade cells, with thickened, smooth, entire walls. Then come the spindle cells, at first having but few pores, but with pores increasing in number as the cells are viewed in succession, until the position *b*, Fig. 6, is reached, where they are very numerous. In a thin portion of the section, as represented in Fig 8, the middle lamella between two adjoining cell walls is plainly seen, showing that pores from adjoining cells meet at, but never pass through, the lamella, which remains as a thin membrane entirely closing each cell. Occasionally an oblique septum will be found in a spindle cell, as in two instances in Fig. 8, like a little disc on a slender shaft. This appearance is caused by the section of a thickened septum, with a pore on either side next the cell wall. Fig. 9 is an enlarged view of a few cells, also from the transverse section, taken near the position *b*. The walls are more thickened, and the pores are far more numerous. Fig. 10 gives an enlarged view of two of the globular cells at the position of *c*, Fig. 7. They are not as globular as usual, but they show the structure well. The surrounding walls are excessively thickened, and the pores are very numerous. This is the most dense portion of the entire internal structure. The appearance of the wall between the two cells, and of the outer wall of the lower cell, is of quite frequent occurrence. The middle lamella is stouter through this dense portion of the endosperm than at other positions, and takes the stain deeply. And the pores sometimes, as in this case, are so frequent and so close together, that the section of the adjoining

portions of the cell wall gives the appearance of beads strung on a stout wire. Fig. 11 shows a few of the polygonal cells of the brown substance of the cleft, taken from the last portion of the transverse section at *d*, Fig. 7.

The longitudinal-radial section so closely resembles the transverse section that it would be very difficult to distinguish them if the labels were removed from the respective slides. Therefore the description of one will answer well for the other, showing that the cells of the inner structure are successively prisms, spindles, and irregular globular cavities.

The longitudinal-tangential section presents quite a different appearance. Fig. 12 shows a small portion of such section, taken quite near the surface of the stone, but after several successive slices have been removed. The left-hand portion of the figure represents the outermost layers of the seed coats. First are found long, fusiform, hyaline cells, presenting no marked structure with high magnification. Then succeed still longer, attenuated cells, with much thickened cell walls, minute lumen, and exceedingly abundant capillary canals running from the lumen to the middle lamella, there meeting similar canals from adjoining cells. Fig. 13 gives an enlarged view of three such canal cells. These cells and the succeeding cells of the seed coats do not always lie parallel with the longitudinal axis of the stone. Usually they are longitudinal, but frequently they are disposed in groups, which branch at various angles, until sometimes they are directly transverse, parallel with the smaller circumference of the stone. Next within the canal cells follow large, irregularly elliptical, dark-brown cells, with slightly pitted walls, and usually disposed in two layers. Then follow more dense tissues, of short, fusiform, hyaline, and light-brown polygonal cells, until we come to the outer ends of the palisade cells of the endosperm, and, as the section dips a little deeper, the outer extremities of the spindles are seen as little circles, of various sizes according to the position in which they happen to be cut, and all imbedded in the dense structure of the thickened cell walls. Fig. 14 gives an enlarged view of the cut outer ends of these palisade cells and spindle cells, as they appear in this longitudinal-tangential section.

The hard structure furnished by the thickened walls of this endosperm is said to be pure cellulose. The interesting fact alone

remains to be mentioned that the extremity of the seed leaf, remaining in the germinating date-stone, enlarges, dissolves the hard cellulose, and conveys it as nourishment to the growing plantlet, until the entire stone is emptied of its contents. This action, however, although strikingly displayed in this case, is not peculiar to the date-stone alone. It is common in some form to seeds provided with an endosperm, which take up their nourishment in germination from the endosperm by special organs, which are always parts of leaves.

PROCEEDINGS.

MEETING OF MAY 6TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-six persons present.

Dr. Carl Heitzmann was elected a Resident Member of the Society.

On motion the thanks of the Society were tendered Mr. Morris K. Jesup, President of the Board of Trustees of the American Museum of Natural History, for his kindness in granting the use of the Halls of the Museum Building on the occasion of the late Annual Exhibition of the Society; and also to Messrs. Louis P. Gratacap and William Wallace for their invaluable assistance on the same occasion.

Mr. Carlton C. Curtiss read a paper entitled "The Anatomy of the Stem of *Wistaria Sinensis*." This paper is published in full in this volume of the JOURNAL, p. 79, and was illustrated by microscopical sections of the wood of the stem, as indicated below.

OBJECTS EXHIBITED.

1. Transverse section of one-year-old stem of *Wistaria Sinensis*, showing pith, medullary sheath, xylem, phloem, periblem, and dermatogen.

2. Transverse section of the wood, showing transition from duramen to alburnum.

3. Radial section, showing spiral tracheids of medullary sheath.

4. Tangential section, showing wood-elements, tyloses, medullary ray, etc.

5. Tracheids, isolated by Schultze's fluid.

6. Tracheæ, showing halo, canal, and thickening membrane.

7. Transverse section, showing cork, bast, etc.

8. Radial section, showing crystal and resin sacs of bast.

9. Tangential section, showing origin of cambium.

10. Transverse section, showing beginning of anomalous growth.

11. Transverse section, showing growth from cork to bast to wood to bast to wood, illustrating the theory of the paper.

Exhibits 1–11 by CARLTON C. CURTISS.

12. Transverse section of stem of *Amphilophium*, and two photomicrographs of the same: by E. G. LOVE.

MEETING OF MAY 20TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-six persons present.

Mr. George W. Kosmak was elected a Resident Member of the Society.

Mr. William Wales, referring to the letter of Mr. H. R. Spencer, dated Buffalo, N. Y., January 27th, 1891, and published in the Proceedings of the American Society of Microscopists, said that he desired to verify the statement of that letter that Mr. Spencer, Senior, who was the father of the manufacture of microscope objectives in this country, constructed lenses of fluorspar at that time—the summer of 1860. From his personal knowledge he could verify the fact that Mr. Spencer made the said one-eighth objective for Dr. Rufus King Brown, and also a one-quarter objective, of 175° air angle, with perfect color correction, containing a fluorspar lens, for Dr. Louis Tice, which objective is now in the possession of Dr. Charles E. West, of Brooklyn.

The Corresponding Secretary presented a communication, dated May 5th, 1892, from Mr. K. M. Cunningham, of Mobile, Ala., describing seven slides prepared by Mr. Cunningham, and donated by him to the Cabinet of the Society, as follows:

"1. A slide of diatoms from Selma, Ala. The city overlooks

a high chalk bluff on Alabama River, and at numerous points on the bluff fresh water constantly trickles down its face. Wherever this is the case there is a streak of living diatoms in constant growth on the chalk. The species associated, as shown on the slide, are as follows: *Synedra fulgens*, *Cymbella cymbiformis*, *Cocconema lanceolatum*, *Navicula parva*, *N. veneta*, *Gomphonema capitatum*, *Nitzschia panduriformis*, *Suriella ovata*, a *Cocconeis*, and two species of *Melosira*.

"2. A slide of silicified coniferous wood, derived from gravel of river drift overlying chalk at Gainesville, Ala. A fine polariscope object.

"3. A slide of fossil marine diatoms, completely pyritized, and which completely dissolve in nitric acid, leaving no structural traces. These diatoms were derived from a stratum of miocene clay encountered at a depth of 700 feet in the third artesian well, recently finished at Mobile. This find of mine corroborates a fact of geological interest, as pyritized diatoms were recently found near the Atlantic seaboard, in artesian borings, at Brentford and Clayton, contiguous to the Delaware River. The diatoms, as mounted, are relucent like gold when examined by surface condensed light, and species of the following genera may be seen: *Coscinodiscus*, *Actinophticus*, *Triceratium*, *Pleurosigma*, *Navicula*, and *Synedra*, indicated by outline and surface depressions, as the specific reticulation is masked by the pyritous deposit.

"4. A slide to place upon record the character of the marine sedimentary silicious deposit from St. Stephens and vicinity, Alabama. This tripoli is one of the strata composing that portion of the tertiary formation known as the buhrstone, which traverses the States of South Carolina, Georgia, Alabama, and Mississippi. On this slide may be seen about 175 selected diatoms, polycistina, and foraminifera, showing their metamorphosed state by mineral infiltration.

"5. A slide showing numerous polycistina from the same sedimentary stratum. On the same slide the crystalline grains show bands of prismatic colors arranged axially. Under polarized light the bands of color waves travel from the periphery to the centre, or *vice versa*, as the polarizer is revolved from right

to left, or the reverse, offering a prettier phenomenon than is offered by common silicious sands.

"6. A slide showing two species of foraminifera from Bon Secour Bay, inside Mobile Bay. These shells seem to be built up with minute plates of mica, well marked under polarized light by color contrasts.

"7. A slide showing inclusions in flint. This slide was prepared as follows: Very thin flakes were detached from a flint nodule, put on the slide, and immersed in gelatin. After twenty-four hours the gelatin had dried to a thin pellicular coating, after a manner polishing the flint chips. A drop of balsam was then added and the cover glass put on. The gelatin pellicle prevented the penetration of the balsam, and assisted in retention of air in the various spicular spaces. The slide shows a variety of organic inclusions, and an ink dot marks the spot where three *Xanthidia* are grouped together, and can be easily found with a one-sixth objective. It is nearly as easy to trace out the inclusions when so mounted as it would be with a polished section of flint."

Dr. E. G. Love exhibited on the screen, with appropriate descriptions, projections of 100 lantern slides of photomicrographs of various objects.

MEETING OF JUNE 3D, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Sixteen persons present.

Rev. J. L. Zabriskie read a paper entitled "Notes on the Structure of the Fruit-stone of the Date, *Phœnix dactylifera* L.," published in this volume of the JOURNAL, p. 107, and illustrated by diagrams and microscopical preparations, as noted below.

OBJECTS EXHIBITED.

1. Sections of Cementstone from Sandai, Japan, prepared from material donated to the Society by Mr. K. M. Cunningham: by JAMES WALKER.

2. Section from fossiliferous Chert, prepared from material donated to the Society by Mr. Cunningham from St. Stephens, Ala., of concretionary structure, and a replacement of some fossil forms of Chalcedony: by JAMES WALKER.

3. Transverse section of the Fruit-stone of the Date, *Phœnix dactylifera* L.

4. Longitudinal-radial section of the same.

5. Longitudinal-tangential section of the same.

6. Transverse section of the same, showing the embryo *in situ*.

Exhibits 3–6 by J. L. ZABRISKIE.

Mr. James Walker donated to the Cabinet of the Society the two slides donated by him, as stated above.

MEETING OF JUNE 17TH, 1892.

In the absence of the President and Vice-President, Rev. J. L. Zabriskie was elected chairman.

Twelve persons present.

The Corresponding Secretary presented a paper by Dr. Alfred C. Stokes, entitled "A Note on a variety of *Salpingœca gracilis* J.-Clk." This paper was illustrated by beautiful drawings, and is published in this volume of the JOURNAL, p. 101.

OBJECTS EXHIBITED.

1. *Nitella*, showing unusually fine circulation.

2. *Melicerta ringens.*

3. A colony of *Limnias ceratophylli.*

4. Larva of *Dytiscus marginalis*, young.

Exhibits 1–4 by STEPHEN HELM.

5. Section of fossil Coral from Chautauqua, N. Y.: by JAMES WALKER.

PUBLICATIONS RECEIVED.

The American Monthly Microscopical Journal: Vol. XIII., Nos. 6—8 (June—August, 1892).

The Microscope: Vol. XII., Nos. 6—8 (June—August, 1892).

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Bulletin of the Torrey Botanical Club: Vol. XIX., Nos. 7, 8 (July, August, 1892).

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The Ottawa Naturalist: Vol. VI., Nos. 3, 4 (July, August, 1892).

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The Victorian Naturalist: Vol. IX., No. 1 (May, 1892).

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Indiana Medical Journal: Vol. XI., Nos. 1—2 (July—August, 1892).

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Johns Hopkins University Circulars: Vol. XI., No. 100 (July, 1892).

Le Diatomiste: No. 9 (June, 1892).

Revue Internationale de Bibliographie Médicale: Vol. XIII., Nos. 11—13 (June 10—July 10, 1892).

American Lancet: Vol. XVI., Nos. 7, 8 (July, August, 1892).

National Druggist: Vol. XX., No. 12—Vol. XXI., Nos. 1—4 (June 15—August 15, 1892).

Mining and Scientific Review: Vol. XXVIII., No. 23—Vol. XXIX., No. 8 (June 9—August 25, 1892).

Weekly Bulletin: Vol. I., No. 47—Vol. II., No. 58 (June 11—August 27, 1892).

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NOTES ON CORDYLOPHORA LACUSTRIS AND MELICERTA RINGENS.

BY STEPHEN HELM.

(*Read November 14th, 1892.*)

CORDYLOPHORA LACUSTRIS.—Prof. Allman is, I believe, the only scientist who has investigated the life-history of *C. lacustris*, and although nearly forty years have elapsed since those investigations were made public, they still stand alone. This is attributable in all probability to two causes: first, the exhaustive character of that memoir; and, second, the rarity of the form itself—the former rendering observers shy of entering upon ground already so ably trodden; the latter placing a very effective barrier in the path of those who might have felt inclined to investigate had circumstances favored them.

Notwithstanding this, and the expressive and derisive representation applied to certain persons who "rush in where angels fear to tread," I am desirous of placing on record some observations made during the past summer, and I venture to hope I may be forgiven for re-introducing this form to the Society after so short an interval.

To make the present remarks clearer I am compelled to refer to my paper published in the April number of the JOURNAL, in which I speak of my anxiety to complete my observations on cer-

tain new forms therein mentioned, at the earliest possible moment. With that idea I have made repeated visits to the locality in search of specimens, although as yet without result. On one of those visits, that of July 17th, however, I took comfort to my soul, for on peering into the canal I perceived a form which, from its general aspect and enormous numbers, I at once jumped to the conclusion was my long-desired *C. coronata*. But on transferring a colony to one of my bottles for closer examination, to my amazement I found that instead of *C. coronata* I had *C. lacustris*, about the very last form I should have expected. In the paper referred to, on these two forms, I have said that after the most painstaking and diligent search I was only able to find one solitary specimen of *C. lacustris*—and that by accident—amongst the tens of thousands of *C. coronata*. But here I had before me *C. lacustris* enough to supply every microscopist in the world to his heart's content and a few millions of millions over; for although prospecting only on one side of the canal for convenience, it was, for a couple of miles at least, literally lined with it. Wherever there was a resting-place there were the tiny but beautifully branched stems of *C. lacustris*. That I was pleased, nay, delighted, goes without saying, and dreams of a thorough side-by-side comparison of the two forms rose before me, being now sure that, as I had had the good fortune to find *C. lacustris*, I should find *C. coronata* also.

Is there *any unmixed* joy in this world? I pressed the cup of joy—not canal-water—to my lips, but the pleasure was evanescent, being soon embittered by disappointment; for, after two hours' careful search, *C. coronata* was still "conspicuous by its absence." I could not find even one solitary specimen to console me. On reaching home I prepared a tank for my new capture, filling it entirely with the water obtained in this expedition—about a gallon—and looked forward to a grand distribution during the week amongst the members of the New-York Microscopical Society and other friends, even going so far as to make a careful list of those who I knew would value it. Alas! now followed my second disappointment. I had reckoned without my host. The next day my collection looked queer, and I thought it best to defer my distribution. And well it was for my friends I did so. For in three or four days *C. lacustris* was defunct and the water vile enough and black enough for Styx.

Nothing daunted, even though the weather was still very hot, I made another visit. That collection "hurried up" and went bad the following day. Again and again I tried, but, from some inexplicable cause, every gathering went in the same manner, and finally *C. lacustris* went also, gradually disappearing from the canal. I did hope to secure some germs at least, but the only result I to-night have of all these rich hauls, and after some eight or ten visits, is a piece of weed in spirit, which originally carried a few hundred forms, three to six on a stem. This I exhibit to give an idea of the enormous numbers in which it was found.

What investigations I was able to make confirmed a good many of Allman's illustrations. But I found two points of difference, otherwise the Society would have been spared a narration of my experiences.

One point of difference relates to the general position of the tentacula, which were spread in all directions and presented a free, wavy appearance, as in *C. coronata*. As shown by Allman—see April JOURNAL, plate 30—they stand almost vertical, whilst in my "solitary specimen," exhibited November 6th, 1891, they stood out like wires from a telegraph pole. Some few specimens which I was able to retain up to ten days ago had the same free, wavy appearance. Allman's presentation, however, may have been an accidental difference, produced by exceptional environments, and I do not lay much stress upon the point.

But the second point, as to the numbers of the tentacula, seems to me an important one. Allman very strangely omits to specifically state the number of tentacula, except in his description where he says, "Polypi tentaculis numerosis sparsis teretibus," thus leaving it to be inferred that, although numerous, their number is uncertain. And yet in his illustrations, of which he gives four, one, an immature form, is figured with thirteen, whilst of the three matured forms one is figured with twelve and two with thirteen. So that, to say the least, tentacula are "an uncertain quantity." But it is not unfair to Allman to assume that he considered thirteen the maximum number. Now, I found in these captures the tentacula varied in number from ten to twenty, and of these latter so many instances as to convince me that it was not an abnormal number, but quite common. However, that this statement might not go forth on my unsupported testi-

mony, I requested Dr. Pierson, my medical adviser, to count them also, and he confirmed my observations.

To sum up: This experience is certainly one of the strangest I ever passed through. Here is one form—*Cordylophora coronata*, and a new one—existing in countless millions, and for months together, in 1891, disappearing altogether in 1892; whilst the typical form *Cordylophora lacustris*, represented in 1891 by solitary specimens, appeared in 1892 in the same countless millions, but only for a few weeks. Is it possible that in these facts we have an illustration of "alternation of generations"?

MELICERTA RINGENS.—In a contribution to the *Quarterly Journal of Microscopical Science*, Philip Henry Gosse described for the first time the building-up of the tessellated tube of this lovely form of rotifer, which took place under his very eyes. Although nearly every writer on this form since that time quotes more or less from Gosse, I am not aware that any other observer has witnessed the complete operation.

I have felt a desire to do so all my life, and have searched amongst Melicertians hundreds of times, in the hope that I might be so favored, but in vain. At last, on July 26th of this year, I had the ambition of my life gratified. At 10:30 A.M. I perceived a young specimen busily engaged in this interesting occupation. Six rows of pellets had already been completed, and the young builder was still hard at work. I watched this combination of brickmaker, architect, and builder at work for five hours uninterruptedly, which I claim was, for so small and so young an operator, an unparalleled feat even amongst the hard-worked mammalians. To be sure, the object, the establishment of a home, and that for a lifetime, was a noble one, and who would not vigorously labor for such a purpose? However, dropping reflections, suffice it to say that at the expiration of these five hours the young artisan rested, evidently considering "the house" high enough for the present, and then proceeded to devote "the wheel of life" to the acquisition of food.

But what had been accomplished in these five hours? Starting with six rows of pellets at the time of first observation, twenty-one rows more were piled up, viz., fourteen rows up to 1:30 P.M., and seven more up to 3:30 P.M. These consisted, as near as I could

count, of twenty-four or twenty-five each on the average, giving a total of over five hundred pellets.

My experience confirmed that of Gosse, that the time occupied in forming a pellet averaged about one minute, for there were short intervals, as you will hear presently. The deposition was accomplished by a sudden jerking of the head, but so rapidly that I could not determine the precise instant of deposit. When we consider that the material for the formation of these pellets had to be gathered from the surrounding medium, in which scarcely a trace could be discovered—literally a case of "making bricks without straw"—it would seem a stupendous effort. All through, the same perfect order in deposition, the same delicately graduated and enlarging diameter, which we are so accustomed to admire in Melicertians, had been maintained—one more proof of the unerring instinct bestowed by the Omniscient Architect on the first Melicertian that ever built its case on these lines, and which had descended through countless generations to the one now before me.

Prof. Williamson says the first rows of these cases are deposited upon a "thin hyaline cylinder, the dilated extremity of which is attached to the supporting object." Now, with his paper and illustrations before me, I looked very carefully for this cylinder, all through the process of building, but looked in vain. A support of some kind seems essential on which to agglutinate the first pellet, and from it the first caudal row of pellets. For although adhesion to each other by means of the viscous secretion employed can be understood, they would hardly keep in position without some attachment. But, assuming the existence of this "thin hyaline cylinder," another difficulty arises, that of completing the connection between the tube and the base on which it is designed to finally rest, when the cylinder would manifestly be in the way. Gosse does not mention such a "cylinder," but the omission is accounted for by the fact that he witnessed the construction from a vertical point of view.

Whilst I entertain the highest regard for Prof. Williamson's paper and for his general erudition, I beg respectfully to say that the after-process I observed leads me to a different conclusion. When I first observed the tiny worker the lowest row of pellets was the $\frac{1}{120}$ of an inch from the base of operations. After three hours' labor in building, this had been reduced one-half. At the

expiration of five hours, and the termination of its labor, the interval had vanished altogether, and the junction of the case with the base to which the animal still adhered by its suctorial disc was complete. It seems to me that a "hyaline tube," on which the first rows of pellets are said to be deposited, must first be constructed, and that when these rows are completed it would have to be got rid of in some way, unless the intervening space were filled up by continuing to build upon it downward, which idea was not warranted by my observations.

The conclusion I am led to is that the first pellet is held in position by a temporary attachment, proceeding from its own body, in some unknown manner, and so situated as not to be in the way when its purpose is accomplished. My theory was produced by observing the singularly beautiful manner in which the tube was brought down. At short intervals the little builder ceased "making bricks," and, suddenly contracting itself upon its adhering tail, pulled the tube down with it for a short distance. By these repeated contractions and efforts the interval was gradually reduced, until the connection with the base was made and the work finished.

We have hitherto been accustomed to account for the tapering construction of the case solely by the different diameters of the body and the tail, but it is possible that a double purpose led to the conception of the design, viz., the lessening of labor in building, and the facilitation of the "pulling-down process" I have described, which latter is no doubt materially aided thereby. Of course it will be asked why the Melicertian does not solve the difficulty by laying the foundations of its tube upon the base on which it finally rests. I simply reply, I don't know. But I also add that, on October 2d, I had the pleasure of seeing another young Melicertian engaged in building, and I also observed the same interval between the caudal end of the tube and the base.

THE CAUSE OF ASIATIC CHOLERA.

BY LOUIS HEITZMANN, M D.

(*Read October 21st*, 1892.)

Before Koch's great discovery of the "comma bacillus of cholera Asiatica" many different views were held as to the cause of cholera: first a gas theory, then a miasma theory, a soil theory, and so on, each finding its supporters. In 1884 Koch announced the fact that a "comma bacillus," or rather a "spirillum," found only in the intestines of patients and their discharges, but neither in the blood nor in any other organ, was the sole cause of the disease.

Under the microscope the comma bacillus proves to be a small, somewhat curved rod, in the fresh state often forming long curved threads, and hence its name "spirillum." It is best colored with either fuchsin or methylin blue. Microscopical examinations, however, are not conclusive. A number of other bacteria, such as Finkler and Prior's comma bacillus of cholera morbus, Deneke's comma bacillus found in cheese, Gamaleia's *Vibrio Metschnikoff* found in the intestines of fowls, or Miller's comma bacillus isolated from the mouth, can often not be differentiated, looking almost exactly alike.

Cultures are necessary for an absolutely certain differential diagnosis. Koch has shown that his comma bacillus grows on gelatin in an entirely different manner from that of the other comma bacilli. On the plate small colonies develop in from eighteen to twenty-four hours, which have a pale color, darker in the centre, with a slightly uneven contour, and soon look as if studded with particles of glass. These increase in size, and soon the gelatin commences to liquefy in the centre, forming a small funnel, the gelatin having sunk below the level of the surrounding portions. In a stick culture the same features take place. The funnel in the centre becomes larger and larger, the upper portions apparently becoming filled with an air bubble. The liquefaction of the gelatin goes along slowly, and only by about the sixth day the whole of the upper portion is liquefied.

All other comma bacilli grow differently on gelatin. Finkler

and Prior's liquefies the gelatin very quickly; Deneke's and the *Vibrio Metschnikoff* not quite as fast as Finkler and Prior's, but faster than Koch's; and Miller's not growing at all. Koch's spirillum also grows on agar-agar, milk, serum, potatoes, and, in fact, on almost any cultivating medium, if not too greatly diluted. It needs oxygen, grows best at a temperature between 60° and 105° F., is completely destroyed at a temperature of 140° F. in ten minutes, only grows on neutral or slightly alkaline media, and is soon destroyed by drying.

The last feature shows that it cannot spread through air. It can only act when introduced through the mouth into the stomach. It can be destroyed by sublimate (1: 2,000), carbolic acid (half of one per cent), chloride of lime, sulphuric acid, etc. The disease can be prevented with comparative ease. All contact with infected material must be absolutely avoided, and such material thoroughly disinfected. The hands must be kept scrupulously clean, and all water must be boiled before use. The stomach should be kept in good condition, as the comma bacillus will be destroyed in the stomach if the latter performs its functions normally.

PROCEEDINGS.

Meeting of October 7th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-eight persons present.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, dated Houston, Texas, September 29th, 1892, accompanying a donation to the Cabinet of the Society of a slide of pyritized diatoms and foraminifera, as follows:

"I forward a slide of marine diatoms and foraminifera, pyritized, or metamorphosed. They are derived from a stratified clay, at a depth of about thirty feet, in the deepening of the slip in front of the new grain elevator at Galveston, Texas. The natural submarine strata were removed by powerful suction dredges, and discharged in a continuous flow into the adjacent lowlands, with the object of securing deeper water and at the same time of reclaiming a littoral marsh for railroad purposes. In the expul-

sion of the liquid marine mud and sands, numerous large masses of the stratified clay were discharged through the twelve-inch discharge pipes, and an examination *in situ* revealed the presence of the pyritized diatoms and foraminifera. In order to put the interesting occurrence on record, I prepared a selected slide, showing about fifty of the fossilized remains, and this is the only one I had leisure to prepare. With a one-fourth objective and condensed light a pleasant and instructive study may be made of the metamorphism of forms which were once of silicious and calcareous nature.

"Putting this locality upon record extends the known area of distribution for mineralized diatoms. The earlier known specimens were from the London clay basin. Mr. Lewis Woolman's researches in the artesian-well area of the New Jersey coast have extended the subject for that locality. What I have previously put on record with your Society, for the artesian area of Mobile, Ala., has disclosed its further areal extension. And my present contribution from Galveston Bay continues the chain, to be carried on by others interested in the subject.

"I noted the following genera : *Coscinodiscus*, *Actinoptychus*, and *Campylodiscus*, but did not observe a single *Triceratium* in my limited study of the material."

Mr. Cornelius Van Brunt donated to the Cabinet a photographic negative of *Pleurosigma angulatum*, taken with a Natchet immersion, No. 7 lens, by the late Samuel Jackson. Mr. Van Brunt also placed before the Society a cabinet of one hundred and fifty microscopical slides, of the collection of Mr. Jackson, which his family now offered for sale to the Society, and stated that Mr. Jackson was one of the best preparers of microscopical objects, and, until near the time of his death, was one of the most active members of the American Microscopical Society of the City of New York. It was proposed to purchase the collection of slides for the Cabinet of the Society, the expense to be defrayed by subscription.

OBJECTS EXHIBITED.

1. Section of leaf of *Hoya carnosa*, with crystals of calcium oxalate.
2. Transverse section of stem of *Hoya carnosa*.
3. Transverse section of petiole of *Aspidestris*.

4. Pipette Filter, for the easy manipulation of hæmatoxylin, anilin green, etc.

Exhibits 1–4 by FRANK D. SKEEL.

5. Codfish, entire, three days old, from the Biological Laboratory at Wood's Holl: by H. W. CALEF.

6. Photomicrograph of the epiderm of the stem of Geranium: by CARL HEITZMANN.

7. Pyritized diatoms, from Galveston, Texas, prepared by K. M. Cunningham: by J. L. ZABRISKIE.

8. Stinging hairs of the larva of *Empretia stimulea* Clemens, the "Saddle-back Caterpillar": by J. L. ZABRISKIE.

Dr. Skeel stated, concerning his exhibit of *Hoya*, that the plant belongs to the Palm family, and that the sections were stained with anilin green, the fibro-vascular bundles taking the green, while the other structures remain unstained.

Dr. N. L. Britton referred to the great abundance of sclerotic cells in the stem of *Hoya*, and said that Dr. Northrup, using the same stain as Dr. Skeel, was examining this stem near the time of his death, attempting to find the origin and function of these sclerotic cells.

Dr. Skeel also explained the Pipette Filter contrived and exhibited by him.

Mr. F. W. Leggett gave some observations on Paradise Fish reared by him in an aquarium, remarking upon the dissimilarity of the male and female, and upon their quarrelsome disposition.

Dr. Bashford Dean stated that in 1840 a French officer brought home a pair of these fish in an ice-pitcher; that they are now abundant in the aquaria of Europe; and that they show most remarkable endurance of foul water and careless treatment.

Dr. Carl Heitzmann explained that the photomicrograph exhibited by him was taken under a power of 1,000 diameters, and illustrated the reticular structure of the protoplasm, and the so-called "intercellular connections" in the stem of Geranium, and continued as follows:

"The reticular structure of animal protoplasm I demonstrated first twenty years ago, although S. Stricker, of Vienna, succeeded two years since in reproducing the reticulum in a living, colorless, coarsely granular blood-corpuscle of a proteus, by means of the electric microscope, with a power of 2,500 diameters. In Ger-

many this fact is not yet generally acknowledged. In this country Dr. Alfred C. Stokes, of Trenton, N. J., has recently described the reticular structure of red blood corpuscles of man after treatment with dilute solution of bichromate of potash, as first discovered by Louis Elsberg twelve years ago. The same author has described the reticular structure in *Pelomyxa*, an amœboid protozoan quite common around Trenton.

"In the speaker's laboratory Mr. Maximilian Toch has studied the structure of vegetable protoplasm for more than a year, and has succeeded in photographing this structure by new methods, which he will soon publish. The specimen exhibited was treated with one-half of one per cent solution of chloride of gold, and afterward with sulphuric acid. The reticulum has assumed a dark violet color, and appears dark in the photograph. In many places numerous delicate spokes are seen traversing the cellulose, or cement substance, interconnecting the reticulum of all so-called 'cells,' and thus rendering the plant a continuous individual, from the tips of the leaves down to the ends of the rootlets. This fact was first established by Louis Elsberg in 1883. The connecting threads are far more numerous than represented by Walter Gardiner, also in 1883.

"Since in the animal organism all so-called 'cells' are of a reticular structure, and all basis and cement substances are pierced by a similar reticulum of living matter, we readily understand the fact that, after liquefaction of the basis substance, its protoplasmic condition is re-established. This happens in inflammation, as proven by the speaker in 1873. Quite recently Prof. Grawitz, of Greifswald, Germany, has rediscovered the appearance of 'cells' in the basis substance of fibrous connective tissue in inflammation, dubbing them 'slumbering cells.' The discovery is twenty years old, and was ignored in Germany for no other reason but that it proved the fallacy of the cell theory and the cellular pathology."

Prof. Edmund B. Wilson, Ph.D., of the Department of Biology, Columbia College, being introduced to the Society by Dr. N. L. Britton, related some observations on the germinal cells of *Amphioxus:* Hans van Vleich, of Zurich, observed with regard to the sea-urchin that, at the two-cell stage of the egg, if these cells were shaken apart, each cell produced an embryo of one-half the

natural size. Last summer Dr. Wilson repeated this experiment in the case of *Amphioxus*. If the two cells are simply disturbed the result will be two embryos; and so, in the four-cell stage, the result will be four embryos, showing an original connection between the cells.

Meeting of October 21st, 1892.

The Vice-President, Mr. Charles S. Shultz, in the chair.

Forty persons present.

Mr. William Wales was elected Recording Secretary *pro tem.*

The Corresponding Secretary presented a communication from Mr. K. M. Cunningham, accompanying a donation to the Cabinet of two slides of diatoms, and dated Houston, Texas, October 12th, 1892, as follows :

" Notes explanatory of two slides of diatoms :

" 1. Slide of *Terpsinoë musica* Ehrbg. On the occasion of a visit to San Antonio, Texas, in the spring of 1887, I secured a specimen of a filamentous alga from the fresh water, flushing ditches permeating the streets of San Antonio. Without knowing what I had secured, I forwarded the material to Mr. C. L. Peticolas, who returned me beautifully prepared slides of *T. musica*, and at the same time solicited a larger quantity of the material. I found it impossible to secure any one who could procure additional material from the same locality. But recently, in August, 1892, while on an excursion to San Antonio, I visited the San Pedro Springs and tested for the presence of *T. musica*. I promptly verified the fact that it grew in the greatest abundance on the water plants choking up the shallow waters of the miniature lake. I secured a rake and landed a mass of *Myriophyllum*, which I allowed to dry in the sun. This I took to Houston, and in a month or more found leisure to make a reduction for the diatoms therein.

" A little acquaintance with the diatoms occurring in this freshwater lake enables me to tabulate the following species, which may be seen on the slide sent herewith : *Biddulphia lævis*, *Cymbella gastroides*, *C. affinis*, *Cocconeis scutellum*, *Gomphonema capitatum*, *Cymatopleura elliptica*, *Melosira crenulata*, *Navicula nobilis* and others, *Nitzschia panduriformis*, *Synedra ulna*, several species

of *Suriella*, *Stauroneis phœnicenteron*, *Terpsinoë musica*. But the slide is characterized by the richness of this last species.

"At least forty years ago Dr. Ehrenberg noted the occurrence of *T. musica* in the rivers of Texas. But only a year ago it was announced in *The Microscope*, under the warrant of a leading New Jersey diatomist in his criticism of a popular article in regard to the distribution of the various genera, that *T. musica* was an exclusively marine genus. This statement met with no denial, so far as I am aware of. The park resort at San Antonio derives its name from the San Pedro Springs, which are bold, fresh-water springs flowing from fissures in a cretaceous, fossiliferous stratum. The flow is so great that it is conducted in bridged ditches, or small canals, through the heart of the city of San Antonio, a mile and one-half distant. The little pleasure lake is, of course, fed by these springs.

"Having placed with the Society two typical representative species or varieties of that American *T. musica*, a field is presented to diatomists to make a comparative study of this genus, with a view of noting the biological divergence between the Mobile River, Ala., marsh deposit of *T. musica*, and the San Antonio *T. musica*. M. J. Tempère, editor of *Le Diatomiste*, Paris, has already in print critically classed the Mobile marsh species as being more nearly related to *T. intermedia* Pantcschek than to the ordinary type of *T. musica* Ehrbg.

"2. The other slide sent herewith is derived from an excavated lake bottom, the result of cutting a canal, or artificial 'cut-off,' to reclaim a large area of land subject to periodical inundation, and now to be filled in for railroad station grounds, at Houston, Texas. The lake traversed by the canal once formed a part of White Oak Bayou, and only in the period of high water in the bayou the bayou and lake became coterminous. In low-water periods the lake had a restricted area, containing living mussels, salamanders, etc. Through whatever period the lake may have survived, it became the receptacle for many kinds of microscopic vegetable remains and seeds, as well as a diatom deposit, surrounded on all sides by barren red and white, silicious, sandy strata.

"The slide, while containing hundreds of frustules, was predicated upon the examination of a dry clod of the earth, on the sur-

face of which just one frustule could be made out. At a second visit I found streaks in which the clay partook of the nature of a richer clay, the frustules being easily seen because densely packed.

"The interest in this deposit is somewhat intensified, as the apocryphal '*Navicula craticula*,' or '*Suriella craticula*,' is quite abundant therein, as may be noted on the slide. The other former congeners, *Navicula cuspidata* and *Stauroneis phœnicenteron*, form a majority, which characterizes the slide. Together with these there are species, such as *T. musica*, *Nitzschia circumsuta*, *Cymatopleura elliptica*, *Navicula nobilis*, *N. major*, and a number of other species, as mentioned in the list of San Pedro Springs. Gen. J. D. Cox has investigated the question of *N. craticula*, and, I believe, regarded it at one time as possibly an internal plate or an integral part of *N. cuspidata*, a matter which also interested Dr. D. B. Ward in its solution. He communicated to me, what he regarded as probable at the time, that he had found *N. craticula* in the Montgomery, Ala., fossil, fresh-water earth, where he had not at the time been able to detect *N. cuspidata*.

"Frustules of *N. craticula* occur on the Society's slide, having one-eighth the length of *N. cuspidata;* and likewise frustules of *N. craticula* as large as *N. cuspidata*. The *N. cuspidata* of this deposit are relatively very large and strongly lined, and, side by side with *Stauroneis phœnicenteron*, are very striking under study. Duplicates of either of these slides, in the hands of expert systematists, would furnish data to extend present knowledge or clear up disputed and doubtful points, as the case may be."

The Corresponding Secretary also presented an additional communication from Mr. Cunningham, accompanying a donation of packets of gravel, and dated Houston, Texas, October 14th, 1892, as follows:

"A visitor at Houston, Texas, would be at once impressed by the immense use made of a certain kind of coarse gravel as ballast for the various railroad tracks, and for surfacing the streets of the city; and, if he were a mineralogist, he would at once recognize the presence of petrified wood richly associated with this gravel. In order to place them before the Society, I have made a selection of about a dozen different specimen varieties of these very highly silicified woods. The specimens present some-

thing of structural interest even on casual examination, and they are likewise well adapted to making very fine thin rock sections. This gravel is brought from near Leadbetter, Lee Co., Texas, not far from the Colorado River, and the bulk of the gravel is of a flinty nature, seeming to be of calcareous fossil strata, altered through silicification.

"I have sent, with the fossil wood, a specimen of oölitic and foraminiferal flint, nearly equal in translucency to the chalk flints of the British coast, which can be taken as a type of the flinty gravel of the Colorado River basin.

"In another package I have sent five specimens of a cretaceous or calcareous gravel from San Antonio, Texas, where it is extensively used in the park walks and the pavements around the city. Most of this gravel is in the shape of ovoid or spherical balls, and, if broken in two, are found to be composed of concentric, spherical, concretionary layers, that may be detached continually until the central core, or nucleus, is found. In the specimens sent I have polished each face, to show the peculiar crystalline deposit, from the central nucleus to the outer margin. The two larger pieces are from the one original, and may be fitted together to illustrate the ovoid shape. Inspection suggests that thin sections, when examined with the polariscope, would give concentric radial color effects, which would prove quite interesting. I noticed that children in San Antonio played with them as marbles, using, of course, the roundest that could be found.

"These gravel specimens possibly illustrate a recomposition product of calcareous strata, as in limestone caves, and then, while in solution, redepositing upon some granule or fragment as a nucleus, and gradually augmenting by the same law of calcareous deposition indefinitely, as the balls vary from very small to very large, in the general mass of gravel as distributed. Single and double centres of concretionary action may be noted in the several specimens."

OBJECTS EXHIBITED.

1. *Micrococcus pneumonicus* Friedländer, under a Zeiss one-twelfth homogeneous immersion lens: by CHARLES S. SHULTZ.

2. *Bacillus tuberculosis*, under a Spencer one-tenth homogeneous immersion lens: by CHARLES S. SHULTZ.

3. Comma bacillus, × 900: by LOUIS HEITZMANN.

4. The "S" form of the same, × 1,000: by LOUIS HEITZMANN.

5. Test-tube cultures of the same: by LOUIS HEITZMANN.

6. Slide of mucous membrane of a patient in Calcutta: by L. SCHÖNEY.

7. Photomicrograph of the same: by L. SCHÖNEY.

8. Radial section of the thallus of *Nostoc sphericum* Vauch: by J. L. ZABRISKIE.

9. Living specimens of the same in water: by J. L. ZABRISKIE.

Dr. Louis Heitzmann, of New York, being introduced by the Vice-President, read the paper announced on the programme, entitled "The Cause of Asiatic Cholera." This paper is published in this number of the JOURNAL, page 7.

Dr. George M. Sternberg, of Brooklyn, being introduced by the Vice-President, gave many interesting and valuable points of information on the action and prevention of cholera. He stated, with other items, that the spirillum is quickly killed by desiccation. If little squares of infected blanket are exposed to sunlight two, three, and four hours, it is found that the spirillum will grow after two hours' exposure, but not after four hours' exposure. Sunlight is one of the best disinfectants. In the late operations of the quarantine of our port many articles of clean linen were injured by the steam process, when a little sunlight would have been equally effective. In future operations, doubtless, sunlight would be much employed. With ordinary care nurses of cholera patients do not contract the disease. There is no great danger from germs wafted over in the air from an infected region.

A discussion of the subject also ensued, participated in by Dr. Carl Heitzmann, Dr. Louis Heitzmann, Dr. L. Schöney, Rev. George E. F. Haas, and others.

On motion the thanks of the Society were tendered Dr. Louis Heitzmann and Dr. George M. Sternberg for their interesting addresses.

MEETING OF NOVEMBER 4TH, 1892

The President, Mr. J. D. Hyatt, in the chair.

Twenty-six persons present.

Dr. Arthur Mead Edwards was elected a Corresponding Member of the Society.

The following Committee on Annual Exhibition was appointed by the Chair: Dr. E. G. Love, Dr. F. D. Skeel, Mr. Charles S. Shultz.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, dated Houston, Texas, October 28th, 1892, accompanying the donation of a package of tripoli, as follows:

"I forward to the Society a cabinet specimen of tripoli derived from a superficial outcrop near Navasota, Texas. After having submitted it to a micro-analysis I am able to present the following points of interest in relation thereto. The deposit presents a striking interest geologically, as it appears to be of composite origin, as developed during its analysis. Ninety per cent of the mass may be regarded as made up of what may be alumina in its most highly divided state, or, if not alumina, an amorphous silica, all of which may be completely removed by elutriation. The heavier sediment remaining is found to be volcanic glass, or some like product of igneous fusion, as indicated by its physical characters, viz., complete transparency, flat angular fragments, freedom from admixture with the ordinary silicious, rounded, and abraded grains derived from the decomposition of the azoic or granitic rocks, and whose protean distribution is known to all who have made sands a study. The particles composing this glass are further characterized as being thin plates, filled with vesicles and tubuli, which are very evident in any of the media used in an examination of the same. Examined dry (in air), the vesicles or minute bubbles are very evident, while in balsam they are nearly obliterated. Likewise the tubuli in balsam are differentiated or made quite plain, and finally become indistinct as the balsam invades the air channels of the tubuli; and if the study is made with bisulphide of carbon as a medium, the fragments and plates show with double intensity. (The bisulphide of carbon I refer to is used for patching shoes, and costs ten cents a bottle anywhere, and is called 'quick cement,' and offers a useful medium for the immediate study of diatoms, giving intense and brilliant images before evaporation takes place.)

"If it be admitted that this glass is of volcanic origin, we must necessarily recur to the conditions under which it became a part of this deposit. To do so we are brought face to face with the hypothesis of volcanic dust showers, transported through aerial

currents from distant centres of eruptive activity, and finally settling down on some aqueous area, as a gentle and intermitting rain of mineral particles, during a lengthy period of time. The deposit from which the specimen came is five feet in thickness, and is known to underlie a relatively wide area. Intimately associated with this mineral basis are several kinds of fossil organic microscopic remains, as smooth, non-tubercular, arcuate sponge spicules, crystalline spheres, intermediate in their characters between the polycistinæ and the fossil gemmules of sponges. The spheres have in some instances surface ornamentation of minute bosses, and in others short pyramidal processes or points, giving them a stellate appearance. These spherules had never hitherto been observed by me in any of the many preparations of fossil earths examined. I also saw a few discs, which may be diatoms, but they were unfamiliar shapes to me.

"Touching what has preceded, it is a matter of geological record that in the territory contiguous to the cañons of the Colorado River, and between the Rocky Mountains and Sierra Nevada, there have been observed vast deposits or strata of fresh-water infusorial origin, alternating between beds of volcanic tuffs, lava, and other phenomena of volcanic activity characterizing the struggle between the igneous and aqueous elements for supremacy, in that rock-ribbed region of the earth, now in a state of comparative quiescence. The deposit varies in its composition. Some of the material is as white as chalk and has no admixture of alumina to bind the grains together, and it can be dissipated as dust by dry brushing. When a mount of this is made it shows purely the glassy, angular plates, and nothing else. The economic value of the deposit, either as tripoli or kaolin, has not been overlooked by the commercial instinct, and a sample of the porcelain made from it, and just received from England, shows that it is not adapted to making white porcelain or china-ware, as a cube of it burned into a sort of salmon-colored, translucent glass. A previous trial of it at Pittsburg reported it as unfit for porcelain ware, on account of an oxide of iron that contaminated it."

On motion the thanks of the Society were tendered Mr. Cunningham for this donation and communication.

Mr. Stephen Helm read the paper announced on the programme,

entitled "Notes on *Cordylophora lacustris* and *Melicerta ringens*.' This paper was illustrated by objects under microscopes and by blackboard drawings, and is published in this number of the JOURNAL, page 1.

OBJECTS EXHIBITED.

1. *Octocella libertas* Helm, living: by STEPHEN HELM.
2. *Cordylophora lacustris* Allman, living: by STEPHEN HELM.
3. *Lagotia cæruleus* Helm, living: by STEPHEN HELM.
4. *Lophopus crystallinus*, living: by F. W. DEVOE.
5. Statoblasts of the same: by F. W. DEVOE.

Dr. Romyn Hitchcock, a Corresponding Member, being called upon by the President, gave some reminiscences of the time of his resident membership, and complimented the Society on its vitality and industry.

Mr. F. W. Devoe called attention to the beautiful action of the statoblasts of *Lophopus crystallinus* in his exhibit, revolving inside their gelatinous sacks by means of cilia inserted on the margin of the disc between the anchors.

Dr. F. D. Skeel explained a substage, made for him at his suggestion by the Bausch & Lomb Optical Company, consisting of a plain circular stage with clips, to be inserted at pleasure in the substage ring of the microscope, of great usefulness in operations with low powers, avoiding the extreme racking back of the body and the risk of overturning the instrument.

PUBLICATIONS RECEIVED.

The American Monthly Microscopical Journal: Vol XIII., Nos. 9, 10 (September, October, 1892).

The Microscope: Vol. XII., Nos. 9, 10 (September, October, 1892).

The Botanical Gazette: Vol. XVII., Nos. 5—11 (May—November, 1892).

Natural Science Association of Staten Island: Proceedings, Meetings of September 10, October 15, 1892).

Bulletin of the Torrey Botanical Club: Vol. XIX., Nos. 9—11 (September—November, 1892).

Insect Life: Vol. V., Nos 1, 2 (September, November, 1892).

Psyche: Vol. VI., Nos. 198—200 (October—December, 1892).

The Observer: Vol. III., Nos. 10, 11 (October, November, 1892).

Anthony's Photographic Bulletin: Vol. XXIII., Nos. 17—22 (September 10—November 26, 1892).

Cornell University Agricultural Experiment Station: Bulletins Nos. 42—44 (September, October, 1892).

Agricultural Experiment Station of Alabama: Bulletin No. 38 (July, 1892).

Agricultural Experiment Station of Michigan: Bulletin No. 87 (September, 1892).

Agricultural Experiment Station of Iowa: Bulletin No. 17 (May, 1892).

Agricultural Experiment Station of Texas: Bulletin No. 21 (June, 1892).

Academy of Natural Sciences of Philadelphia: Proceedings, Part II. (April—October, 1892)

Journal of the Franklin Institute: Vol. CXXXIV., Nos. 803, 804 (November, December, 1892).

Bulletin of the Essex Institute: Vol. XXIV., Nos. 4—6 (April—June, 1892).

Transactions of the Massachusetts Horticultural Society: Parts 1, 2 (1892).

The Post-Laramie Beds of Middle Park, Colorado: by the author, Whitman Cross (October, 1892).

Journal of the Royal Microscopical Society: 1892, Part 5.

International Journal of Microscopy and Natural Science: Vol. II., Part 16 (October, 1892).

Grevillea: Vol. XXI., No. 97 (September, 1892)

Proceedings of the Natural History Society of Glasgow: Vol. III., Part 2 (1892).

Penzance Natural History and Antiquarian Society: Report and Transactions (1892).

North Staffordshire Naturalists' Field Club: Report and Transactions, Vol. XXVI. (1892).

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The Naturalist: Nos. 206, 207 (September, October, 1892).

Canadian Record of Science: Vol. V., Nos. 3, 4 (July, October, 1892).

Geological Survey of Canada: Annual Report, Parts D, N (1891).

The Ottawa Naturalist: Vol. VI., Nos. 5—7 (September—November, 1892).

Le Diatomiste: No. 10 (September, 1892).

The Victorian Naturalist: Vol. IX., Nos. 4—6 (August—October, 1892).

Australian Museum: Records, Vol. II., Nos. 2, 3 (August, 1892); Report (1892).

Naturhistorische Gesellschaft zu Nürnberg: Proceedings, Vol. IX. (1892).

Société Belge de Microscopie: Bulletin, Vol. XVIII., Nos. 8—10 (June—October, 1892); Annals, Vol. XVI. (1892).

Le Botaniste: Vol. III., Nos. 2, 3 (August, 1892).

La Notarisia: Vol. VII., No. 31 (June, 1892)

Nuovo Giornale Botanico Italiano: Vol. XXIV., No. 4 (October, 1892).

Bulletino della Società Botanica Italiana: No. 7 (1892).

Revue Internationale de Bibliographie Médicale: Vol. XIII., Nos. 15—21 (August 10—November 10, 1892).

Wissenschaftlicher Club in Wien: Monatsblätter, Vol. XIII., No. 11—

Vol. XIV., No. 1 (August—October, 1892); Ausserordentliche Beilage, Vol. XIV., No. 1 (1892).

L'Académie d'Hippone: Bulletin No. 24 (1888—1890); Comptes rendus (March 30, 1892).

Sociedad Científica "Antonio Alzate": Memorias, Vol. VI., Nos. 1, 2 (1892).

Feuille des Jeunes Naturalistes: Vol. XXII., Nos. 253—263 (November, 1891—September, 1892).

The Satellite: Vol. VI., Nos. 1—3 (September—November, 1892).

Indiana Medical Journal: Vol. XI., Nos. 3—5 (September—November, 1892).

The Hahnemannian Monthly: Vol. XXVII., Nos. 10—12 (October—December, 1892).

The Brooklyn Medical Journal: Vol. VI., Nos. 10—12 (October—December, 1892).

Johns Hopkins University Circulars: Vol. XII., No. 101 (November, 1892).

The American Lancet: Vol. XVI., Nos. 9—11 (September—November, 1892).

National Druggist: Vol. XXI., Nos. 5—10 (September 1—November 15, 1892).

Mining and Scientific Review: Vol. XXIX, Nos. 9—21 (September 1—November 24, 1892).

The Weekly Bulletin: Vol. II., Nos. 59—71 (September 3—November 26, 1892).

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY

VOL. IX. APRIL, 1893. No. 2.

SUGGESTIONS IN MICROSCOPICAL TECHNIQUE.

BY ALEXIS A. JULIEN, PH.D.

(*Read January 20th*, 1893.)

In microscopical investigation of organic structures, success largely depends, sometimes entirely, on their approximately perfect preservation in the form of mounted preparations. In the living organism or a freshly cut slice of tissue, details of the utmost importance may be entirely invisible, which could, however, be clearly brought out only by skilful staining, by patient experiment in search of the most suitable medium for mounting, or by long-continued study under varied methods of illumination or with persistent efforts at resolution, to which only a suitably and permanently mounted object could be subjected. The main object, then, in perfection of permanent mounts, must be, not beauty, nor even the permanent preservation of an interesting object, but, above all, the retention and revelation of its true structure. Unfortunately this has not been the prevailing opinion in all laboratories of investigation; students are often found to have been encouraged or permitted to content themselves, and save time, with some hurried and careless method or step, at a point short of a perfectly completed mount.

The way in which a microscopist finishes, or even merely labels a mount, may often indicate his degree of care and skill in the preced-

ing preparation of the object, and its real value. It is from the point of view, therefore, that no pains can be taken too great for the proper completion of a mount, that the following suggestions are offered on methods devised and mostly in use, for several years past, in the Laboratory of Microbiology of Columbia College, New York. Some of these have been carried over the country by our graduates and so made known to a certain degree, but, to my knowledge, have not been otherwise published.

I. *Carrier of Cover-Impressions.*

In the collection of cover-impressions of various organisms, in the field, such as films of diatoms just spread upon thin covers, desmids, blood corpuscles, pollen, etc., it is sometimes impos-

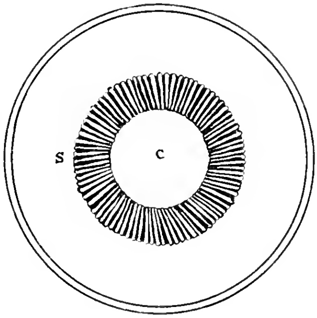

FIG. 1.

sible, while travelling rapidly, to dry the covers and safely pack them up at once for conveyance in small boxes, in the usual way. On one occasion, five years ago, while collecting upon covers the mycoderm-films of certain bacteria and fungi in the hilly country of Western Massachusetts, I felt the need of some convenient apparatus for immediate storage of the covers, while still moist, so that they might be carried with safety, without adherence, abrasion of the film, or breakage. A hint of a convenient method came from a note by F. L. James[1] on a simple cover-glass holder, consisting of a coil of brass spiral spring wire, bent around a groove in a cork, the whole being mounted upon a little wooden stand for laboratory use. This suggested the little carrier here presented (Fig. 1), in which the cork (C), encircled by the

[1] Jour. Roy. Mic. Soc. (1887), 693.

spring (S), is wired to the bottom of a small, round pasteboard box. A thin, loose roll of soft Japanese paper against the inner side of the box prevents the dislodgment of any covers inserted in the coils of the spring; and the box, when closed, can be easily carried in the pocket.

II. *Gas Mounting-Stand.*

In place of the small mounting-table with alcohol lamp, ordinarily used by the microscopist, the little adjustable mounting-stand with gas attachment, here exhibited, has been in use for several years in our laboratory, having been somewhat modified from time to time until it has reached this form. It has the advantage of economy, especially in laboratory use with young students, on account of its tiny gas-jet; it is portable, adjustable, and easily taken apart; convenient in the long retention of heat by the sand-box attached beneath the mounting-plate; and affords support on the ring for small evaporations, or for gentle warming or digestion, when the ring is adjusted over the mounting-plate. A thumb-screw attachment to the arm of the burner, for clamping it to the upright rod, might be convenient, but is easily dispensed with. In the form here shown, the stand has been made for us for some time, both in New York and Philadelphia, and has probably been elsewhere supplied by the manufacturers.

The improvement I have now to present consists in the conversion of the burner, which is often objectionable on account of its smoky flame, into a minute Bunsen burner an inch in length. This is easily accomplished by slipping over the nipple a little tube of brass foil, easily made by any one in a couple of minutes, or, better, of brass tubing, of about six millimetres in diameter, with two small air-holes, on opposite sides, near the bottom, as in a Bunsen burner.

The blue, hot, and clean flame thus obtained is not only best fitted for ordinary heating in microscopical processes, as for burning off the soiled point of a mounting-needle, without soot, but is particularly useful in bacteriological manipulations. Thus, the drying of bacteria-films upon covers is commonly done by passing the thin cover back and forth, three times, through the comparatively huge flame of an ordinary Bunsen burner, at the speed of "a knife cutting bread." In place of this rough method, the

covers are laid by us a certain time, say five seconds, on the mounting-plate, heated at the height of five centimetres above the miniature Bunsen burner with a flame one centimetre in height; or directly over this flame, at a certain height for a few seconds. The heating in this way is far more uniform than by the common method, the films are well dried but not roasted, and more satisfactory results may be expected in the subsequent staining. What could be a more disproportionate, wasteful, and absurd process than the common one of warming a tiny thin cover, of the size of one's little finger nail, over a rush of flame six or seven inches in height!

III. *Staining-Flask.*

The staining of films which have been dried upon covers, such as bacteria or blood corpuscles, especially when heat is required, often leads, by the common methods, to imperfect or erroneous results in inexperienced hands. Sometimes the stain, after having been heated up in a test-tube, is thrown in a watch-glass, and the cover floated upon it, film downward (Gibbes' method).

The usual method is to hold the cover, with the film uppermost, between the fingers or in a forceps, add a drop or two of the stain, and heat over a low flame until steaming vapors rise from the stain. Though simple, this is troublesome where many films need staining at one time or in succession. There is also a tendency of the stain to dry in an overheated ring around the edge of the cover as well as to deposit granules of color, which, in some cases, adhere firmly to the film and cannot be removed by washing. This is more likely to occur when long heating is needed to stain the object to sufficient depth of color; the little drop evaporates rapidly, and constant attention is needed to keep it supplied with fresh additions of stain.

In place of these methods, the following simple apparatus has been in satisfactory use in our laboratory for many years. It consists of the following parts:

1. A tight coiled spring (Fig. 2, A), as a cover-holder, in which a large number of thin covers may be clamped by insertion between successive coils. It is made from a spring of fine brass, copper, or steel wire, not coarser than No. 26 gauge, wound on a one quarter inch mandrel. It is best made from fine platinum

wire, of the usual gauge for blowpipe-work, its temper having been removed before the winding, and restored afterward by quick annealing, plunging while red-hot into cold water. The wire at one end of the coil is bent into a little loop for suspension. After long continued use, the platinum wire has the special advantage of being easily purified and retempered by heating to red heat and again plunging in cold water.

2. A small, wide mouthed flask (Fig. 2, B) to hold the staining-solution. This may have a capacity of about forty cubic centi-

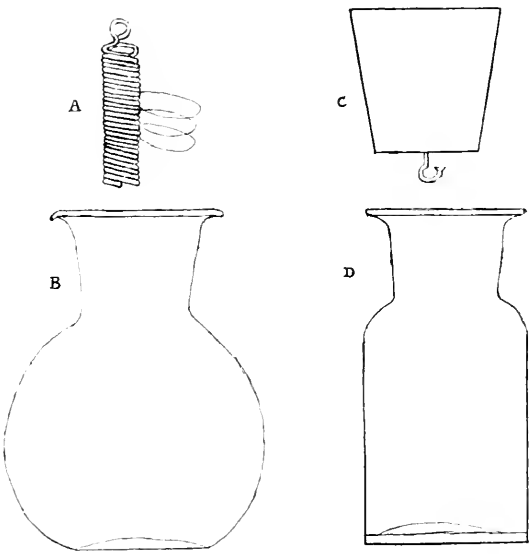

FIG. 2.

metres, with an aperture at the mouth of at least two centimetres. To this a wide cork (Fig. 2, C) is somewhat loosely fitted, on the under side of which is stuck a pin bent into hook-form, from which the coil A may be hung. This flask, when in use, is kept about two-thirds filled with the desired staining-solution.

3. A wide mouthed, glass-stoppered bottle (Fig. 2, D), of the same aperture as the flask, to hold the second solution, which is often required, as a mordant.

For example, in the staining of bacteria-films dried upon covers, the flask B will receive the solution of campechian or other stain, and the bottle D the mordant solution of sodium

chromate or tannin ; or, in Löffler's method, B the hot mordant, and D the colorant. The covers are to be first firmly inserted in the coil with the help of a knife-blade, with the films downward, and so suspended from the cork. In the campechian staining method, the stain in the flask is previously brought up to the boiling point by holding it a few minutes over a flame. The cork is then inserted, making sure that the covers remain entirely immersed in the hot stain. The apparatus is left upon a mounting-table, so heated as to keep the liquid very near or just below the boiling point, and there allowed to remain for the length of time desired in any particular case, which may even be an hour or more. A large number of covers may be thus stained at one time, with little needed attention. The cork is finally lifted out of the flask, and the coil, without removal of the covers, is plunged into successive beakers of distilled water until the covers are thoroughly washed from excess of stain. Then the glass stopper is removed from the bottle and replaced by the cork, so that the coil with its burden of covers now remains plunged in the mordant for the requisite time.

It may be added that the staining-flask is useful as well in many cases where there is call for long and slow staining of films on covers in a cold solution. The handling of thin covers in mass, by this method, rather than individually, is found to diminish greatly their liability to breakage.

IV. *Condensed Air-Film.*

We have next to consider a long neglected source of the air-bubbles which form a constant annoyance to the working microscopist. At times they may only indicate the content of air originally dissolved in the cold preservative, expelled by warming it, and likely to be entirely reabsorbed in the course of time, after the cooling of the mount. Frequent instances of this occur, especially in the use of warmed glycerin jelly, melted Canada balsam, and dammar. More commonly they may be derived from entanglement with the fibres of a filamentous object, enclosure in the pores or empty cells of a cellular object, or simply from mechanical attachment to the cell-wall or to the cover, overlooked in hasty mounting without sufficient use of the pocket lens. Their neglect in such instances may injure the appearance of a mount and inter-

fere with observation, by the coalescence of several minute fixed bubbles into a large movable one. This may lead to harm by weakening the mount, disturbing the object as the bubble rolls about, and tending to foster germ-life for its destruction.

In cases, however, of extreme care toward their avoidance, the experienced microscopist has been repeatedly surprised and disgusted by the mysterious appearance of minute air-bubbles, in a hermetically sealed mount, from some unknown source. To that source I would call attention, in the film of condensed air and moisture which has been shown to be firmly attached, under ordinary conditions, to the surface of all solid bodies, and which has been best studied on the surface of metal and glass.

The following precautions are taken in our laboratory against this invisible enemy :

1. As the air-film can be removed by friction, all plain slides and the interior of cells are briskly rubbed just before using. The microscopist unfamiliar with the difficulty would content himself by merely dusting an apparently clean slide.

2. The stock of glass covers is thoroughly cleaned at one time by immersion in Seiler's solution (one part saturated solution of potassium dichromate in three parts of concentrated sulphuric acid) for about an hour, thorough washing successively in common and then in distilled water, and immersion in strong alcohol. In the latter the covers are allowed to remain, in a wide mouthed glass-stoppered bottle of about thirty cubic centimetres capacity. Just before use each cover is taken out and well rubbed, dried, and placed on a warm mounting-table, so that it may be applied to the mount chemically and microscopically clean and entirely devoid of the air-film, which ordinarily soon becomes condensed upon a cold glass cover.

3. All preservatives are kept slightly warmed just before use, and the object is soaked in distilled water recently boiled and cooled, and therefore strongly absorbent of air.

The insertion of a mount in a vacuum, under the bell-jar of a convenient air-pump, for a short time just before it is to be covered, is a useful precaution, especially with an object consisting of more or less tangled fibres, or of a cellular character with partially empty cavities. But I have not found that the condensed air-film can be removed in that way.

V. *Supply Can for Sterilized Non-aërated Water.*

A little flask, fitted as a wash-bottle, will usually suffice to supply a small quantity of water, recently boiled, cooled, and free from dissolved air.

But when there is need of a less fragile apparatus for more constant or larger supply, and, especially in bacteriological research, it is desirable to have at hand a reservoir of sterilized water, the following apparatus will be of service. A cylindrical can (Fig. 3), made of copper or tin, and of any desired capacity, is covered with a tightly fitting cap, which can be removed for cleaning the

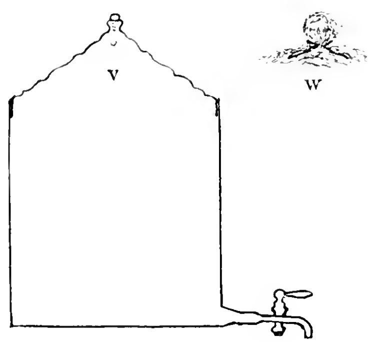

FIG. 3.

interior. In the centre of the cap an automatic escape-valve (V) for steam is inserted. From the side of the can, at the bottom, a supply-pipe runs out a few inches horizontally, ending in a faucet. The can, thoroughly cleaned and scalded out, is nearly filled with distilled water and heated over a burner to boiling, for a couple of hours. While the steam is actively escaping from the valve, a wad of sterilized cotton (W) is quickly wrapped about the valve, and the burner removed. The wad is fastened with a turn of a piece of wire, and a cone of filter paper thrust over the end of the supply-pipe, to protect it from dust. When sterilized water is needed, the paper cone is removed, the end of the pipe flamed, and the faucet turned.

VI. *Mounting Medium for Algæ and Fungi.*

The microscopic objects and structures which receive the at-

tention of the naturalist are constituted, in by far the largest number of cases, of formed, non-contractile material. Even delicate tissues consist, in large part, of sacs, sheaths, or other envelopes enclosing protoplasm or sarcode, but themselves constituted of formed material, such as cellulose, chitin, etc., able to resist heat or partial desiccation or dehydration without much distortion. For the numerous objects of this vastly predominant class many good mounting media have been found. Their sheaths, carapaces, and skeletons being tough and stout enough to resist most of the tendency to distortion produced by the contraction of the minutely divided protoplasm they contain, the processes and the preservatives employed answer a useful purpose. By selective absorption of stains, or by exceedingly delicate contractions or expansions effected by treatment with acids, absorbents of water, etc., particular details of organic structure become peculiarly colored, swollen, or shrunk, and so rendered prominent by contrast and more easily distinguishable. Most histological preparations, for example, by their vari-colored tissues, intensified nuclei, etc., serve to convey supposed or established facts from one observer to others. For such purpose, these methods are legitimate and most useful, but may be, and generally are, just as artificial as those of drawing and photography for the true representation of structure.

But, on the other hand, for the permanent preservation of living contractile matter, without immediate or ultimate contraction and distortion, such as the protoplasmic contents of thin walled cells of fresh-water algæ, water fungi, bacteria, rhizopods, infusorians, etc., no satisfactory medium has yet been found. This is an entirely different problem from that above considered, and for its solution the elements of the higher tissues, with their minute subdivision of contractile matter in granules and cylinders often less than ten microns in diameter, afford too diminutive a field for exact microscopic discrimination of effects produced by various processes and reagents.

But he who attempts to preserve an object like amœba, the cell contents of a desmid or spirogyra, bacteria in zoöglœa, etc., cannot deceive himself in regard to his limited degree of success, as he notices the contracting contour of the comparatively huge mass of protoplasm. Only an object of this class, however, can

serve for a sufficiently delicate test of minute movements in the outline of the protoplasm itself, which, in ordinary objects and in tissue sections, might entirely escape observation.

It is surely possible to predicate and classify the main causes to which must be due the shrinking or swelling, distortion and disintegration, which, sooner or later, are seen in progress within the cells of most mounted preparations of organic material. Thence we may deduce certain principles of selection or exclusion, which we may apply toward the various reagents, mixtures, and solvents which claim fitness for this service. The careful synthesis of formulæ according to this system ought to clear out of our way, once for all, a large number of unsuitable reagents; to put a stop to the concoction of merely experimental formulæ; and to bring us much sooner into possession of satisfactory processes. It is now proposed to offer a brief statement of the chief causes of alteration of organic structures, when immersed in so-called fixing and hardening solutions and preservatives.

1. *Alteration by Change of Natural Conditions or by Death.*— When we attempt to watch and unravel the lovely phenomena of life thrilling and pulsating within the field of the microscope, great care and skill are needed to preserve those natural conditions, within which it is possible, even in the living organism, to recognize the normal forms and relationships of its structure. By any change of temperature, produced by the heat of the room or lamp, or the coldness of the metal of the stand; by lack or excess of moisture, oxygen, or light; by vibration or jar; by offensive vapors in the atmosphere, carbon dioxide gas from the observer's breath, or the volatile solvents that are kept or used in the laboratory; and perhaps by still more subtle but efficient causes of disturbance, morbid and unnatural changes in the contractile matter may be produced which are difficult or impossible to avoid.

But artificial trial by means of chemicals, as fixatives and stains, by dissection and vivisection, however useful or indispensable for study of special elements, tends to be still more fatal to accurate discrimination of protoplasmic forms in general morphology.

And, for this purpose, death ends all; instantaneous coagulation and alteration ensue; our slow recognition of cadaveric

changes is due only to the imperfection of our apparatus and methods. Even the special absorption of certain stains by the living protoplasm of plants and animals is almost always attended with extreme irritation and then their death by poisoning; it is not yet safe to assume that such a death is not accompanied by morbid change, however imperceptible hitherto, in many cases, by our best skill in observation.

Partial success, it is true, has been obtained by the use of paralyzing reagents, such as cocain; but in general, as Hofer observes, "a simultaneous swelling of the protoplasm occurs, so that, although the topographical conditions are retained, the histological details are in many cases destroyed."

A general acknowledgment of the fact, therefore, that a mounted preparation, however useful as an accessory source or illustration of special facts, can only be a mummy, or a slice of a mummy, never a satisfactory substitute for the living protoplasm of the original tissue or organism, would have a tendency to clear the air of much controversial vapor, our literature of interminable discussion, and our life work of a vast amount of wasted labor. It seems at first discouraging, but I think it is true.

The partial success in the past, however, leads us to hope that, by more systematically devised processes and formulæ, we may succeed in arresting protoplasmic change so speedily and thoroughly, as to cause the organisms embalmed in our cells to retain a far more life-like approximation to their original structure. To this end, precaution must be taken to guard against the causes of distortion yet to be considered.

2. *Contraction by Chemical Reaction.*—The jelly-like contents of the cells may be diminished by slow solution or by chemical reactions gradually produced through some constituent of the surrounding medium. Alcohol, in any proportion, should therefore be omitted, on account of its known solvent action upon chlorophyll and other coloring matters; its dilution signifies only delay in solvent attack. Any acid, moreover, especially if inorganic (with a few exceptions, like carbon dioxide), has a tendency to produce contraction; this apparently consists of actual disintegration and destruction of sarcode in time, particularly rapid in that of protozoa, amœba, and the cœlenterata. This tendency may be very useful in bringing out certain structures

by development of contrast. Of this common examples are found in the use of acetic or chromic acid in differentiation of nuclear structure; of picric acid in direct staining of tissues; of osmic acid in fixation of tissues, and in coloration of fat through deoxidation. But there is every reason to believe that the protoplasmic elements, in the tissues or organisms so accentuated or colored, no more remain in their original condition than, for example, the threads of muscular fibre teased out with needles by a laboratory student for the purpose of more easy distinction. In this connection we may remark the significant change of opinion[1] of such authorities as Berthold, Schwartz, Kölliker, and others, on the subject of the true structure of protoplasm, who now look upon the reticulum and fibrils, recognized by Frommann, Arnold, and others in sections of tissues so treated, as being only artificial products.

All these acids, then, together with their salts, such as ammonium and potassium dichromates, and mixtures like Müller's fluid, Erlicki's fluid, Lang's solution, etc., need to be rejected for our present purpose. The only ones likely to be found useful, in high dilution, are such organic acids as exist in living tissues, possibly such as oxalic, malic, citric, etc., in plants, and sarcodic, lactic, butyric, etc., in animals. As a rule, the mounting medium for which we are now searching should probably be neutral in its reaction, for most objects.

This conclusion condemns at once and altogether, for preservation of protoplasmic forms, the use of the resinous media, so excellent for general purposes of mounting—Canada balsam (so often the refuge of the lazy microscopist, wishing to avoid the construction of a cell), gum dammar, copaiba, copal, and styrax. The objection to these is founded not only on their slight content of organic acids, as well as of turpentine or similar solvent, but also on the complicated series of processes required for the preliminary dehydration and subsequent clearing. A glance at the evidences of tedious torture of protoplasm in these long-drawn-out processes ought to be sufficient to account easily for their failure in the permanent preservation, without distortion, of the natural forms of contractile matter within the interior of cells.

We have also to guard against the shrinking of living proto-

[1] O. Bütschli, Sep. Abd. Verh. Deutsch. Zool. Gesell., 1891, 14-20.

plasm in the presence of corrosive agents (in some cases, perhaps, this shrinking inside of a cell-wall being the only movement it has shown in life), as well as that due to "irritability," even after death. The irritating properties of the gold and platinum chlorides, and the strong astringent properties of the alums, on which is founded their usefulness in media for other purposes, are particularly objectionable, in my opinion, on account of the corresponding contraction they produce upon protoplasm. Therefore, for this purpose, I am inclined to reject King's fluid for marine algæ (alum, mercuric chloride, and sea water); Wickersheimer's preservative for algæ, lichens, fungi, etc. (alum, common salt, potassium nitrate, potassium carbonate, arsenious acid, distilled water, glycerin, and methyl alcohol); an alga preservative (chloroform, glacial acetic acid, and distilled water); Pacini's preservative for blood corpuscles (mercuric chloride, common salt, glycerin, and distilled water); Morehouse's preservative for algæ, desmids, volvox, etc. (copper acetate, camphor water, distilled water, glacial acetic acid, and glycerin): Meckel's, for protozoa (chromic acid, acetic acid, platinum chloride, and water); preservative for algæ, characeæ, and infusoria (salicylic acid, wood vinegar, glycerin, and water); preservative for confervæ (chloroform. glacial acetic acid. and water); Ripart's preservative for spirogyra and other algæ (glacial acetic acid, camphor water, and distilled water); preservative for algæ, desmids, etc. (Deane's compound, Ralf's liquid, glycerin jelly, and solution of aluminum acetate); preservative for entomostraca (carbolic acid, alcohol, and water); Goadby's preservative; boroglyceride (boracic acid in glycerin); and a large number of others.

3. *Contraction by Absorption of Water.*—This cuts off at once, it seems to me, the use of all the dehydrating fixatives, hardening solutions and preservatives, *e.g.*, those in whose composition either alcohol or glycerin has been used in any proportion whatever. The fact that some such mixtures have seemed at least comparatively satisfactory to investigators probably shows only that contraction has progressed more slowly and distortion been longer deferred. With half the percentage of the ingredient that is greedy for water, the mounted object is ruined in two years instead of one.

Notwithstanding the recent recommendation of Klein[1] for the

[1] Jour. Roy. Mic. Soc. (1889), 140, from Hedwigia.

preservation of the fresh-water algæ, this is the main objection to the use of pure or diluted glycerin, glycerin and camphor water, camphor water and alcohol, glycerin jelly, Farrant's and Bulloch's media (*i.e.*, mixtures of gum arabic and glycerin), etc. The same objection may probably hold to the more complicated mixtures, such as Heintzch's preservative for desmids, algæ, etc. (alcohol, glycerin, and distilled water), Hervey's preservative for marine algæ (glycerin and sea-water), etc.

4. *Contraction, or, it may be, Irregular Expansion, produced by Osmotic Action through the Cell Wall.*—A most efficient cause of alteration in shape of the colloidal masses inside of the wall must probably lie in this interchange of liquid and soluble matters with the medium outside. The greater the difference in density (commonly aimed at for the sake of contrast in refractive index, with corresponding improvement in definition), as when the external preservative is nearly pure water (*e.g.*, camphor water), or in solubility, as when the preservative is a strong saline solution, the more active the osmosis and the more speedy the deformation. We may consequently expect that solutions of common salt, potassium acetate, aluminum acetate, calcium chloride, etc., and the large number of preservatives made up of complex combinations of sundry salts, must be specially objectionable in this way, where protoplasm forms are concerned; so also, perhaps, even syrup, honey, dextrin, and solutions of gums, to some degree.

5. *Contraction by Heat.*—The more delicate forms of protoplasm, even after death, are commonly sensitive to very slight elevations of temperature. This presents one serious objection to the use of hot glycerin jelly, aside from that founded on the absorption of water by its content of glycerin.

It is, of course, still more efficient for harm in the resinous media, like balsam and dammar, and many others of higher refractive index in which heat is used, such as sulphur and arsenious acid, realgar, etc.

We may, therefore, conclude that any medium requiring a temperature much above 30° C. (say 85° F.) for sufficient fluidity is unfitted for the preservation of protoplasm.

6. *Disintegration by Bacteria and Minute Infusorians.*—In many or most cases a living object, plant or animal, when about to be immersed in the fixing or hardening solution and the pre-

servative, is already covered with myriads of these destructive agents, either mature or in the condition of gonidia, spores, or eggs. In mounts from hands inexperienced in regard to this danger, one can find, long after the preparation was made, an abundance of living forms, particularly bacteria, which must be preying upon the mounted object. To meet this attack some suitable and permanent germicide should be added in proper quantity as a constituent of the preservative.

Mercuric chloride (corrosive sublimate), often used for this purpose, should be avoided, in my opinion, on account of its unstable character, as it gradually loses chlorine and separates from solution in the form of particles of calomel, feebly antiseptic if at all; also on account of its corrosive nature, which tends to disintegrate most forms of sarcode.

Most acids, like carbolic (phenol and thymol), salicylic, picric, boracic, arsenious, chromic, etc., are equally unsuitable, on account of their corrosive nature and acid reaction. Camphor may be of little permanent value, on account of its slight solubility in water solution—*e.g.*, in the form of "camphor water"—and also its ready absorption by organic matter of the walls of the mounting cells.

As to chloral hydrate, there is increasing evidence as to its possession of antiseptic power, as well as tendency to preservation of chlorophyll and coloring matters; while the satisfaction of its affinity for water by a single molecule insures the absence of farther dehydrating power.

There are also several copper salts which seem to possess the same desirable qualities as chloral, especially the chloride and nitrate, and the principal objection to the acetate appears to be its instability.

In our own Laboratory experience, after trial of a large variety of the preservatives in common use, we have found Petit's solution apparently the most satisfactory for the preservation of fresh-water algæ and even colored fungi, with longest retention of both form and color in the protoplasmic contents of their cells. This conclusion is founded on an examination of several hundred mounted preparations of these objects during a period of about fifteen years past. The following is the well known modification [1] of Ripart's published formula :

[1] Internat. Jour. Micr. and Nat. Sci., 3 ser., ii. (1891), 177.

Copper chloride (crystallized)	0.2	gm.
Copper nitrate "	0.2	"
Glacial acetic acid	0.5	"
Camphor water	50	c c.
Distilled water	50	c.c.

Shake up until solution, and filter.

After some time, however, we found it advisable not to use this solution in its full strength, but with the addition of an equal bulk of boiled distilled water. More recently two further modifications of the formula have suggested themselves. First, the glacial acetic acid should be omitted. Secondly, as the two copper salts, even in the chemically pure form supplied in commerce, have ordinarily an acid reaction, the free acids should be neutralized in some way.

It should also be remarked that the nature of protoplasm itself varies so greatly, as to constitution, density, color, transparency, contractility, and other properties, that it is not at all probable that a single preservative of universal application can ever be devised, even for the forms of vegetable protoplasm.

The desirable qualities, in a mounting medium suited to preserve aggregates of protoplasm in their original form, size, and color, as seen within the organic cell, are the following:

Neutral reaction; absence of dehydrating power; density approaching that of protoplasm; fluidity below 30° C.; content of efficient germicide; and very low or very high refractive index. Where, then, can we find this ideal preservative medium for protoplasm? Only hitherto, I think, in the dreams of the hopeful naturalist.

In my own Laboratory our attention has been largely given to the preservation of the fresh-water algæ and water fungi. From former experience we have hopes of success from the following preservatives, now on trial.

A. *Organisms with delicate walls and rather thin and watery endoplasm* (*e.g.*, desmids, beggiatoa, etc.).— A tiny grain of napthalin is inserted, part way but firmly, into the inner side of the cell-wall (paraffin or wax), and only the filtered native or mother water of the organism (or boiled and cooled distilled water) is used to fill the cell. In this we hope to have a substitute for camphor water, with a more efficient and permanent germicide.

B. *Organisms with endoplasm of ordinary density* (*e.g.*, most of the filamentous algæ).—This is a solution founded on experience with Petit's preservative :

Copper chloride	0.1 gm.
Copper nitrate	0.1 "
Chloral hydrate	0.5 "
Distilled water, just boiled	100 c.c.

From this solution, however, the trace of acidity must be removed in this way: Another solution is prepared of a few grammes of any soluble copper salt ; to this a weak solution of caustic potassa is added in slight excess ; the precipitate of hydrated copper oxide (CuH_2O_2) thus obtained is washed thoroughly, first by decantation and then upon a filter. This purified residue is then thrown into the one hundred cubic centimetres of preservative first prepared, and the whole frequently shaken at intervals until a neutral reaction is shown by test papers, and then filtered.

C. *Organisms with Apparently Dense Endoplasm.*—To one hundred cubic centimetres of Solution B add ten grammes of gum arabic, in selected white grains, shake until solution, and filter. Possibly gelatin may be found preferable to gum arabic. The object of thickening the solution is to prevent any tendency to osmosis ; though, of course, the approximation of refractive index within and without the organism may tend to decrease the definition.

VII. *Balsam-Paraffin for Cells.*

The materials commonly used for cell construction, though of excellent application, particularly shellac varnish, gold size, Bell's cement, copal varnish, and zinc cement, are open to two objections.

1. The freshly spun cells can only be used after baking or drying, which may require considerable length of time. This sometimes stretches into weeks or months in the case of gold size, where the process of ripening is mainly one of oxidation.

2. The material, even after thorough drying, is gradually soluble or liable to softening under the action of some of the constituents of common preservatives, particularly alcohol and inorganic acids.

In 1880 we began the use of paraffin for spun cells, and it has

been used continuously ever since in our laboratories. Its decided neutral reaction or indifference toward most chemical reagents renders this a unique material for a cell-wall, from a chemical point of view. It is but slightly soluble in alcohol, though freely in ether, benzol, xylol, and turpentine. It is miscible with fixed or volatile oils when melted, and, I believe, slowly when cold. Fortunately its strong solvents are rarely or never employed in the constitution of preservatives.

The fitness of paraffin for cell-making has repeatedly occurred to microscopists at home and abroad. A few years ago a suggestion of its use for cells was published in a German scientific journal; and more recently it has been recommended by F. N. Pease[1] simply for ringing balsam mounts.

Nevertheless its use appears still to be limited, if not unknown, in many laboratories, and no reference is made to it in the last edition, by Dallinger, of Carpenter's work on "The Microscope." This has been caused, I think, by its insufficient adherence to glass. Early in its use we found this defect indicated, at times, by the inability of a liquid mount in a paraffin cell to bear moderate pressure without easy rupture, generally at the bottom of the cell, next the slide. Paraffin, in cooling, does not form a homogeneous solid, but a congeries of crystals, often comparatively coarse. Its deficiency seemed to call for the addition of some substance of greater adhesive power, whose diffused particles would also serve as nuclei to induce the consolidation of the paraffin in a more minutely crystallized mass. This was easily accomplished by previously saturating the paraffin with one of the strongest cements, balsam-cement; the result has proved entirely satisfactory after use for nearly ten years. The following are the details of the simple method. A supply of balsam-cement is first prepared by slow evaporation of commercial Canada balsam, in a shallow tin pan, over a low flame, until the point is reached of wax-like consistence on cooling, as tested on drops removed and cooled from time to time.

For the paraffin the hardest variety in commerce is used, with highest melting point, above 45° C. (113° F.). After the stock of this (say one-quarter of a pound) has been heated over a low

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[1] Micr. Bull., vii. (1890), 1.

flame to the melting point, a small lump (say nut size) of the balsam-cement is added, and the whole digested at gentle heat, with frequent stirring, for about an hour, until the saturation of the paraffin by balsam is shown by a slight yellowish tinge. This colored paraffin contains less than five per cent. of balsam and is now ready for use; a supply is poured into a shallow porcelain capsule with broad bottom, of about thirty cubic centimetres capacity. When needed, this is heated upon the mounting-table over a very low flame and kept just at the melting point. Overheating should be avoided, indicated by the escape of vapors, as it tends to break up the paraffin into softer forms and also to volatilize the diffused balsam-cement. At long intervals it may be desirable to add a little more of the original hard stock to the capsule, and a very small lump of balsam-cement. A common camel's-hair brush (extra sup. No. 2) is used to transfer the paraffin, and, on account of the low melting point (63° C.), the brush needs no cleaning after use, and, if not allowed to remain too often in contact with the hot bottom of the capsule, it lasts almost indefinitely. In use, the turn table should be placed as near as possible to the capsule, and, if convenient, on the same level. The glass slides on which the cells are to be spun should also be kept warmed upon the mounting-table. If very shallow cells are needed, mere films, suitable for mounting bacteria in potassium acetate, the slides should be hot, and even a slight warming of the turn-table may be of advantage if the room should be cold. Cells may be thus spun at a single twirl of the brush, shallow or deep, in proportion to the load of paraffin on the brush and the mode of its application.

A paraffin cell is immediately ready for use after it is spun; this is one great advantage of the material over all others. Paraffin cells spun in this way are well suited for dry mounts, as they are free from moisture and do not give off the oily vapors whose condensation, in cells made from sheet wax, has been found in time to obscure the under surface of covers.

In using a paraffin cell for a mount with a liquid preservative, the first step is to flatten the top of the cell, which, if the cell is deep, is apt to be convex. This can be done with a stroke of a fine flat file, taking care to remove any loose particles which might be thrown into the cell. This flattened surface

should be then moistened with a mere film of liquid marine glue; the object and preservative then introduced; the cover applied and pressed down into contact with the sticky film of glue; the excess of preservative which has exuded cleaned away with rolled bits of absorbent paper; and a thin seal of paraffin then spun around the joint between the cover and the cell. Both to strengthen the seal, to protect the paraffin with a hard coat, and for appearance, a thin coat of some finish is then spun over the whole surface of the paraffin. This may be colored according to taste, such as red sealing-wax varnish or black asphalt; but in our laboratory a colorless finish is preferred, imparting a porcelain glaze to the cell, such as gold size, liquid marine glue, King's colorless cement, rubber cement, etc. With a paraffin cell one may thus finish the entire mount at once, without the necessity of waiting at any point for cell or seal to dry.

A limitation of the use of paraffin cells lies in the necessary avoidance of oils as preservatives, as in the case of mounting crystals in kerosene or castor oil; for this a cell of shellac varnish or King's cement is best suited. Nor can liquid Canada balsam or gum dammar be used with safety in a paraffin cell, on account of the attack of the turpentine, as a ready solvent of the paraffin wall.

Colored varieties of balsam-paraffin are also of use, especially black, white, and blue, made, respectively, by intermixture with lampblack, with zinc oxide, and with Prussian blue, each thoroughly dried and carefully sifted through a fine lawn sieve. Heavy powders, like white lead and vermillion, cannot be well used, on account of rapid settling to the bottom of the melted paraffin. Even with the three colors above mentioned, the mixture in the capsule must be rapidly stirred just before the brush is loaded.

Only cells of some thickness can thus be made from colored paraffin; but, when the mount has been finally varnished with one of the finishes already stated, the black paraffin assumes a jet-like glaze, and the zinc paraffin a white enamel of great beauty. The latter seems preferable to zinc cement, on account of its uniformity, constant insolubility and impermeability toward most preservatives.

Of course, in the use of paraffin mounts with a projection microscope, the insertion of the alum-cell is desirable, to prevent ele-

vation of the temperature of the slide to a degree near the low melting-point of paraffin.

The balsam-paraffin is well suited for making deep cells by means of the Chapman mould, either in the simple form or colored, *i.e.*, the black or the white zinc paraffin. Two precautions need attention :

1. The mould should be kept well cleaned, and its inner surface rubbed over with a very slight film of vaselin previous to use. This prevents the adherence of the paraffin cell, which comes out readily in perfect form.

2. On account of the low melting point of paraffin, it is difficult, in the ordinary way, to cause the moulded cell to adhere perfectly to the warmed slide, without partial fusion and injury. A paraffin film should be first spun upon the slide, carefully warmed just to the point of fusion, the moulded cell applied, and the whole quickly cooled.

INAUGURAL ADDRESS

BY THE PRESIDENT, MR. CHARLES S. SHULTZ.

(*Delivered January 20th,* 1893.)

It is with much misgiving that I now assume the duties and the honor of the Presidency of this Society. Do not expect me to reach the high scientific standard of the gentleman whose successor I have become, nor the standard of those who have preceded him in the office. I desire, however, that faithfulness and energy may make partial amends for possible lack of talent.

May I then, at the outset, trouble you with a few suggestions which, if heeded, may be of some service to the Society ?

Let us be punctual, so that the meetings may be opened at the appointed hour. Let exertion be made to attend all meetings, whether papers are announced or not. Meetings with unannounced papers or addresses have usually afforded the attendants much pleasure and instruction. Also, a numerous representation infuses a spirit of emulation on the part of those in attendance, and greater results are consequently obtained. Encourage the

attendance of ladies, and thereby increase the social features of our gatherings. To most of you now present the request to attend is superfluous, as you have appeared here with regularity and may be expected to do so in the future. We have, however, numerous members, and among them some of our ablest thinkers, who seldom grace these rooms with their presence, although they occasionally make amends by an excellent paper or address. Should the last-mentioned class appear more frequently, the Society's work would be greatly enhanced, while it would be the means of bringing others here, who would discuss the papers and participate in extending the desirable work now sustained by the faithful few.

Exhibitions of apparatus and demonstrations of manipulation are exceedingly desirable. Even if there is not anything absolutely novel in such presentations, there are doubtless many, not yet adepts, who would thankfully receive the instruction. The expected address this evening by Dr. Julien on "Microscopical Technique," together with the novel apparatus now displayed before us, gives hopes that the influence of this session will be a valuable incentive to the holding of many future "working sessions" Work of this nature was frequently accomplished at the earlier meetings of this Society, the incidents of which our older members will recall with delight.

Let more objects be brought for exhibition. Announcement of these on the programmes is urgently requested. But let not inability to make timely announcement prevent the desired exhibition. In this manner we have frequently received valuable instruction from those engaged in special research, and in the preparation and mounting of special classes of objects.

There are those, whose time is not entirely taken up by their regular avocations, who might derive much pleasure themselves, and be of great service to others, if they would undertake the examination of foods, food products, drugs, textile and other fabrics, with the view of the detection of adulterations and admixtures. In conjunction with a friend, who is an analytical chemist, I have recently had occasion to critically examine white writing papers. In the course of our investigation we have discovered, among other things, that much of the fine paper, water-marked "pure linen paper," is more or less mixed with cotton and other

materials. Upon this subject I may in future give you some particulars.

Let us remember that photomicrography, and the various results, in the form of prints and lantern slides, are always welcome themes that may be demonstrated at the meetings, and that would be received with pleasure by the members generally. I also request that those engaged in the lines of histology, pathology, and bacteriology bring before us from time to time, as Dr. Heitzmann proposes to do at the next meeting, notice of their work in papers on these subjects, which we guarantee will be received with deep attention.

I will not burden you with further suggestions at present. If I shall accomplish nothing more, in the future I will endeavor to infuse enthusiasm in some of our friends who are able to present their good works before you. If each of us will at least add a little toward the general interest, much usefulness and enjoyment will doubtless result, to the benefit of the Society, whose prosperity we all have at heart.

PROCEEDINGS.

Meeting of November 18th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Eleven persons present.

A communication was received from the New York Camera Club inviting the Society to attend an exhibition of the Heliochromoscope, by Mr. Frederick E. Ives, of Philadelphia, to be given at the rooms of the Club on the evening of the 21st instant.

On motion the thanks of the Society were tendered the New York Camera Club for this invitation.

OBJECTS EXHIBITED.

1. Living Spider, held in a lace cage, showing circulation of the blood in the legs: by F. W. Devoe.

2. Crystals of Platinocyanide of Yttrium: by E. G. Love.

3. Cyclosis in *Chara*, showing remarkably good circulation: by J. D. Hyatt.

4. Spherometer, made by the Geneva Optical Company, of Chicago: by F. D. SKEEL.

5. Musical Rasps of the grasshopper, *Conocephalus ensiger* Harris: by J. L. ZABRISKIE.

Mr. Devoe explained the construction of his lace cage for holding small living insects while under observation. The top and bottom are removed from an ordinary paper pill box. The rings, forming the body and the lid of the box, are each covered with a piece of fine lace, kept tightly stretched by having the edges glued down on the outside, and in such manner that, when the lid is placed in its natural position on the body of the box, the two pieces of lace are brought into contact. A small insect placed between the two pieces of lace can be held firmly and yet without injury in any position, and can be examined on the stage of the microscope by either transmitted or reflected light.

Mr. Zabriskie exhibited a female, and the green and brown forms respectively of the male of *Conocephalus ensiger*, and stated, concerning the musical rasps, that in this species, as is common in the green grasshoppers and katydids, the rasp of the left wing cover is much more prominently developed than that of the right. In the slide exhibited the left rasp has eighty teeth, while the right rasp has only fifty-seven. A brown male kept in captivity sang vigorously on the evening of September 30th last. The wing covers were raised very slightly, but were shuffled with extreme rapidity, causing one long note. One such song, timed by the watch, was sustained loudly and continuously, without the slightest break, for the space of four minutes and twenty-five seconds.

Dr. Skeel explained the mechanism and operation of the spherometer exhibited by him.

MEETING OF DECEMBER 2D, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-two persons present.

The President delivered an address on "The Origin and Formation of the New York Microscopical Society." He read from the original copy of the call for the first meeting of the Society, dated November 12th, 1877; from the original copy of the constitution and by-laws, adopted December 21st, 1877; and from the minutes of the first six meetings. These papers were lately de-

livered by the first Secretary, Dr. Romyn Hitchcock, to Mr. Hyatt, who was the first President, being elected on December 11th, 1877, and they were now transmitted by the latter to the Society. Mr. Hyatt in most interesting manner referred to the enthusiasm and work of the early years of the Society, and especially to the efforts made in 1878, finally crowned with success through the good offices of Hon. J. D. Cox, then Congressman from Ohio, to induce the Government to rescind the postal regulations excluding glass slides from the mails.

Mr. William Wales followed this address with reminiscences of the American Microscopical Society of New York City; of the report of the committee on the examination of the vertical illuminator invented by Prof. Hamilton L. Smith; of the persistent search by Dr. Rufus King Brown for the lines of *Amphipleura pellucida;* and of the manufacture by himself, in 1868, of the $\frac{1}{30}$ objective for the Army Medical Museum, which lens lay for ten years in the table draw of Surgeon-General Woodward, but which finally produced the photograph which first showed the resolution of the famous diatom.

The following Committee on Nominations of Officers was appointed by the chair: J. L. Zabriskie, William Wales, F. W. Devoe.

OBJECTS EXHIBITED.

1. Fragment of brown wrapping paper bleached by carbolic acid: by F. W. LEGGETT.
2. Musical Rasps of the Round-winged Katydid, *Amblycorypha rotundifolia* Scudder: by F. W. DEVOE.
3. Section of Lapis-lazuli: by J. D. HYATT.
4. Section of milky Quartz: by J. D. HYATT.

Mr. Leggett explained that the paper exhibited by him was originally of a deep, dirty yellow color, but by the action of the acid it bleached entirely white. This was followed by a discussion on the action of carbolic acid and of peroxide of hydrogen, participated in by Messrs. Ashby, Skeel, Riederer, and Zabriskie.

Mr. Hyatt remarked that the difference between milky and transparent quartz was mainly like the difference between consolidated snow and clear ice, depending upon the preponderance of the inclusions of air, giving the white appearance.

Meeting of December 16th, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-two persons present.

The Committee on Nominations, appointed at the last meeting, reported their nominations of officers for the coming year, and the report was adopted.

The Corresponding Secretary read a communication addressed to Mr. Charles F. Cox, by Mr. Frank B. Carter, of Montclair, N. J., offering to the Society the rare opportunity of purchasing sets of slides of the Radiolaria obtained from the material collected by the "Challenger Expedition," prepared and now for sale by Prof. Haeckel, of Germany.

Dr. F. D. Skeel read an article in the *Medical Record*, issued this day on Photomicrography by Dr. Robert M. Fuller, and exhibited numerous photomicrographs, and also photographic views of the apparatus by which they were taken.

OBJECTS EXHIBITED.

1. Section of tabular Quartz from Thomaston, Georgia: by James Walker.
2. Section of rock-mass, formed by the pressure of the explosive in the bottom of a drill hole: by James Walker.
3. Transverse section of the stem of *Helianthus annuus:* by F. D. Skeel.
4. Transverse section of the stem of *Sassafras officinale:* by F. D. Skeel.
5. Satin leaf from Cape Town, Africa: by F. W. Devoe.
6. Section of oölitic Chert from England: by J. D. Hyatt.
7. Tulip wood, in natural condition, showing tracheids and medullary rays: by T. B. Briggs.

Meeting of January 6th, 1893.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-two persons present.

The Treasurer and the Librarian presented their annual reports, and the reports were adopted.

The President appointed Messrs. William E. Damon and F. W. Leggett tellers of the election. At the closing of the polls

the following persons were declared elected officers of the Society for the year 1893:

President, Charles S. Shultz.
Vice-President, Edw. G. Love.
Recording Secretary, George E. Ashby.
Corresponding Secretary, J. L. Zabriskie.
Treasurer, James Walker.
Librarian, Ludwig Riederer.
Curator, George E. Ashby.
Auditors { F. W. Devoe.
W. E. Damon.
F. W. Leggett.

The retiring President, Mr. J. D. Hyatt, delivered the Annual Address, entitled "Hints of Intelligence in the Movements of Plants." The address was discussed by Messrs. C. Van Brunt, W. J. Lloyd, Rev. G. E. F. Haas, and Drs. Carl Heitzmann and N. L. Britton.

Dr. Carl Heitzmann exhibited a photomicrograph of the endosperm of the Ivory Nut, and remarked upon it as follows:

"It is a curious coincidence that, while the President dwells on the puzzle of the movements of plants, I hold the solution of the puzzle in my hand. It is a photomicrograph made by Mr. Maximilian Toch. The object is a section through the ivory nut, or vegetable ivory, prepared by a method peculiar to Mr. Toch, and to be published by him in due time.

"In an address last May I showed in this Society a photomicrograph by S. Stricker, of Vienna, illustrating the reticular structure of living protoplasm, discovered by myself twenty years ago, and now accepted even by French histologists, as proven by a letter published by Dr. Alfred C. Stokes in the last number of *Science*. What the French term 'hyaloplasma' I have designated as the *living or contractile matter*, and their 'paraplasma' with me is a lifeless liquid filling the meshes of the reticulum. The same features, in a meeting of last October, I demonstrated to be present in the protoplasm of plants, and I showed the delicate, thread-like connections piercing the cement or cellulose, which I have claimed to be formations of living matter, uniting the reticulum in the protoplasm of our so-called 'cell' with that of all neighbors, thus rendering the plant an uninterrupted con-

tinuity of living matter—one individual—and not made up of millions of individuals, as the cell theory had suggested.

"My present photograph demonstrates the interconnection of the protoplasm by threads of living matter traversing the bulky layers of the so-called 'sclerotic cells' of the ivory plant, to perfection, with a power not exceeding five hundred and twenty-five diameters. Even the hardest wood, therefore, is not only supplied with protoplasm, but is rendered a continuous mass of living or contractile matter.

"A peripheral irritation of this substance in certain plants will suffice to produce its contraction, either locally in the leaves or petals, or throughout the whole plant. What we call nervous action is probably based altogether on the contraction of the living matter which, running centripetally, is termed 'neuration,' and running centrifugally leads to motion in the apparatus termed 'muscles.' Motion is again nothing but contraction of the heavy masses of living matter stored up in the muscles.

"The contraction of the living matter is all that is needed for the understanding of the peculiar 'intellectual' movements of plants, which are destitute of both nerves and muscles. The voluntary actions, even in the highly-developed animals, are only automatic."

Meeting of January 20th, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-eight persons present.

Dr. H. G. Piffard was elected a resident member of the Society.

The following were appointed by the chair as Committee on Admissions: F. W. Devoe, William E. Damon, George F. Kunz. William Wales. F. D. Skeel.

The following were appointed Committee on Publications: J. L. Zabriskie. William G. De Witt. Walter H. Mead, John L. Wall, Charles F. Cox.

Dr. Alexis A. Julien read the announced paper, entitled "Suggestions in Microscopical Technique." This paper was illustrated by the exhibition of many pieces of apparatus, and is published in this number of the JOURNAL, page 23.

Dr. Carl Heitzmann replied to certain statements of Dr. Julien, on the uses of acid preservatives, as follows:

"The essayist has spoken rather slightingly of certain acids and their dilute solutions as preservative fluids. Still there is nothing better for the preservation of both animal and vegetable tissues than a half of one per cent solution of chromic acid. Sections through any portion of the plants will be preserved, without noticeable change, by being dipped into the named solution for one or two hours. The most delicate animal tissues, such as chick embryos, from the very beginning of development, can be preserved by being kept first in a one-tenth of one per cent solution of chromic acid, gradually being transferred to stronger solutions, never exceeding one-half of one per cent.

"The brain, spinal cord, the eyeball, and especially the retina are best preserved in Müller's fluid, consisting of one per cent bichromate of potash, two per cent sulphate of soda, and ninety-seven per cent distilled water. This fluid preserves admirably, though it hardens but slowly. Alcohol may be in turn resorted to for the latter purpose. The preservation in alcohol alone is objectionable for microscopical purposes, on account of pronounced shrinkage and abstraction of color.

"Another excellent preservative fluid is a one to two per cent solution of osmic acid, which keeps the minutest structural features unchanged, even in the most delicate (nerve) tissues of animal organisms. Theo. Eimer, of Tübingen, has succeeded in preserving, by means of osmic acid solutions, even the most minute structures of jelly-fish, transferred directly from sea water to the solution. I have specimens of the retina and the spinal cord of man and rabbit, perfectly preserved by osmic acid solution for a number of years.

"As regards mounting media, I concur with the essayist in the statement that we are lacking perfection. The worst used is Canada balsam, strictly objectionable because clearing up the specimens far too much. For the last twenty years I have used nothing but chemically pure glycerin of Merck in Darmstadt, Germany, which, though expensive, yields excellent results. Of course great skill is needed for finding the proper amount of glycerin to fill the space between slide and cover glass. The slightest surplus, oozing forth at the borders of the cover glass, must be re-

moved carefully with moist filtering paper, lest the varnish used for sealing together the glasses peel off after a few years. Glycerin jelly has not answered our expectations, since it renders the specimens blurred.

"For sealing I use nothing but asphalt dissolved in spirits of turpentine. Although black and not looking handsome, this dries within twenty-four hours, and keeps unchanged for a number of years, provided that even the slightest film of glycerin has been carefully removed around the edges of the covering glass. Pretty sealing, although very pleasant to the eye, I consider superfluous."

OBJECTS EXHIBITED.

1. Many pieces of apparatus explained in the paper as above: by A. A. JULIEN.

2. Insect in amber: by F. D. SKEEL.

3. Sections of antenna of the Wasp, *Vespa maculata* L.: by L. RIEDERER.

4. Zentmayer Centennial Stand, with large aluminum stage and certain improvements: by WILLIAM WALES.

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The Microscope: Vol. XII., No. 11—Vol. I., No. 1 (November, 1892—January, 1893).

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SOME PHENOMENA IN EXUVIATION BY THE REPTILES.

BY SAMUEL LOCKWOOD, PH.D.

(*Read May 19th*, 1893.)

In a run through Europe I saw upon a peasant boy clothing that had come down from an ancestor. The garment seemed defiant of wear, but it was painfully malodorous. In nature it is a law for every living thing that the old covering shall give place, at some pretty regular period, to a new raiment. It is similar in principle, whether it be the shedding of the bark of a tree, or the moulting of the feathers of a bird, or the casting of the hard encasement of a crab, or the soft skin of a snake. For this, if the condition is normal, each has its period for laying aside the old and appearing in the new. In the human subject the operation is continuous. I have been surprised, by actual test, at the amount of dermal epithelia floating in the air of a school room, due to the friction from the natural activity of childhood.

Some animals have periodic castings, when the entire outer skin is shed, and the creature then appears in brighter attire. When this process is entire, science, through Huxley, I believe, has given to it the term *exuviation*.

In what will be said on this subject, in the term Reptilia I

shall follow the older meaning, as when it included the Amphibia or Batrachia, simply, however, for convenience.

I recall with what interest, then a young man, the late distinguished palæontologist, B. F. Meek, told me of his witnessing near Albany an old toad taking off his shirt and then swallowing it. He narrated the fact to James Hall, the geologist, who seemed almost incredulous. Since then the spectacle has been seen by a number of naturalists. The sight is truly comical. Bufo, when the time for undressing comes, has his own difficulties, suggesting his need of a valet. The batrachian head is a very immobile thing, much as if it were soldered to the shoulders; for one can hardly say that a frog or a toad has any neck at all. By certain contortions of the creature the skin is caused to crack. The limbs are brought, one at a time, to the mouth, and so the denuding is at last accomplished. The old garment is now badly torn. As the funniest part of the play should come last, so it is now, for Bufo begins a quasi rolling-up process with his cast-off linen, literally tucking it into the mouth, alternately with his right and his left hand. It is at last got into the chest, with as much regard for order as when the husband does the packing of the wife's trunk.

The toad loves the land, but the frog gives much of its life to the still waters; hence the former affords better opportunities for observation when shedding. Like the toad, the frog divests its cuticle in tatters, and devours it, although a contrary statement may be found in the books.

It is a puzzle to divine what may be the significance of this eating its own skin by the reptile. If a stalk of corn be returned to the ground the cuticle gives up a silicate and a phosphate for vegetable alimentation. Is there in the toad's case some conservation of alimentary chemistry? In a day when exact science was not yet born there seems to have been a belief that an extraordinary virtue resided in a cast-off, dirty shirt; for, said a Dr. Van Helmont, "if you put into a vessel a few grains of corn, and stuff into it a dirty shirt, after about twenty-one days the ferment from the dirty shirt, modified by the odor of the corn, effects the transformation of the wheat into full-grown mice." Of course, whatever the marines may do, sailors won't believe that yarn. But the skin of the toad has in it a virtue of a different nature—

the ability to exude an acrid liquid for its defence. It is amusing to note the experience of a dog on his first acquaintance with the creature. If rash enough to seize it in his mouth, the animal will drop it with grotesque expressions of surprise. Perhaps this acrid liquid is a condiment to the cast-off skin, so that what is pungent to Ponto's nose may be piquant to Bufo's tongue. The frog, which is more aquatic, utilizes its skin to aid the lungs in respiration. Thus its cuticle plays an important rôle in the absorption of oxygen from the water, and perhaps the air, and in the evolution of carbonic acid gas.

The true frogs and toads are called *Anourians,* meaning the tailless frogs; for they dispense with this appendage soon after leaving the larval life. They do not, however, drop it or cast it off, but literally take it in. They begin their adult career as severe economists. Sitting on the shore, having for the first time ventured from their watery home, they enter on a veritable newness of life. Each now is a lung-breather. His tail, otherwise useless, is his pabulum for the nonce. This appendage is absorbed—that is, taken into the assimilation, literally eaten, as truly as in his coming days his cast-off cuticle will be taken in.[1]

But there is another branch of this Batrachian gens—the *Urodelia*, the tailed frogs. Such are the efts, the newts, and the salamanders, which retain their tails through life. Thanks to that little eft, the crimson-spotted Triton, which takes so kindly to the aquarium, the act of exuviation may be often witnessed. This Triton, the *Diemyctilus viridescens,* as it seems to me, sheds its skin with an irregular periodicity, doubtless due to food and temperature. Living in the water, it is much easier for these creatures to doff their old clothes than for those animals which do it on the land. When the cuticle has become effete, which in the Tritons is very thin, a little muscular exertion will cause it to stretch, and so admit the water between it and the body, when some wriggling movements will cast it off. It will leave the limbs like tiny gloves, the very toes being preserved in form. Thus this filmy thing floats in mid-water, expanded even to the toes. If we could suppose the tiniest efts doing laundry work, we might liken it to a garment on a clothes line and inflated with the wind.

It must be a canon of Urodelian propriety, for the little Triton

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[1] See note at end.

proceeds to tuck the cast-off vestment into his chest. But this is not allowed by his two companions, so each one seizes a limb. And now all three are pulling on the filmy thing, which in consequence gets put away into three chests instead of one.

It is noticeable how much brighter the colors are after exuviation. The crimson spots are very pronounced and the bronzy green has more of a living hue.

In some stained mounts of the Tiger Triton, *Amblystoma tigrinum*, kindly lent me by Rev. J. E. Peters, the cells generally showed distinct nuclei. Although feeling my ignorance of their significance, I would venture to remark : the *Urodelæ* shed their skin quite often, at least several times in the season. A person told me that he had seen the Red Triton (*Spelerpes ruber*) in an aquarium shed every month. He may possibly have exaggerated. But would not the known frequency indicate a high-growing or vegetative activity in the cuticle? And has not the nucleated cell a higher vital energy than that one whose protoplasm is all simple or homogeneous? Hence this earlier maturing of the Triton's epiderm. So it is here as with the plants—the more rapid the growth the sooner the effete stage is reached.

Leaving these Batrachians, we now come to the Lacertilians. or true lizards, the highest in rank of the Reptilia. Here, too, we find this shedding of the skin, from the great Monitor of the Nile to the little pine lizard that runs on the fence.

I will first instance the so-called Horned Toad, the *Phrynosoma*, which is a true lizard and no toad at all. The sharp-pointed and spike-like projecting scales, which give to the innocent little thing so formidable an aspect, make exuviation of the cuticle in anything like large patches impossible. And so, excepting from the abdomen, which has none of these sharp projections, the cuticle is divested in small pieces and deliberately stowed away.

I wish here to narrate what was witnessed by a friend in the Great Plains. The incident has a psychological interest. and, as will appear, a physiological bearing on our subject. Owing to its sluggishness in captivity the *Phrynosoma* is generally regarded as an utterly stupid creature. My friend saw a female with her young, for which she manifested a striking maternal regard. Alarmed by his presence, she put forth persistent efforts

to get her little ones out of danger by sidling first against one, then against another, until she had them all pushed into a rut of the road. Here the little mother with her young squatted so that they were nearly flat. Had it been a sand bed they would have burrowed out of sight. In this instance the effort was to get out of observation—a quite different thing. In color like the soil, with the tint a little intensified by emotion, they were apparently mere excrescences of the ground.

As the chromic mimicry of the *Phrynosoma* is confined chiefly to one color, I shall speak of it as a monochrome, in distinction from the chameleon, whose mimic power of color is very marked and so is to be called a polychrome. We know that soils in some regions maintain a preponderating color over a large area. It is an interesting fact that *Phrynosomas* of the same species have the one fixed color corresponding to that of their natal soil. As I understand it, the pigment cells, or, literally, color tubes, of the chameleon are of several kinds and deeply seated in the true derm or nether skin. I have under the microscope a mount of the cast skin of the horned toad, *P. cornutum*. It is composed of semi-transparent spaces, erroneously called scales, which, however, is a convenient term. Each of these spaces is bordered by a very much thicker cuticle. The whole is suggestive of a window sash, the transparent parts being the panes and their thick borders the lattice-work. In this thin tissue, more or less crowded to one side of each pane, may be seen the brown pigment granules. They are of one predominating hue and of great quantity, being in the cuticle, while the specimen of cast cuticle of *Anolis* now under the microscope shows no pigment grains whatever. In *Anolis principalis* the panes, as I have called the thin parts of the scales, are much thinner and more transparent, serving, as I conceive, their function for a window through which the color changes can appear when the pigment of the under derm is brought up against them.

I think we may regard the true or under skin of *Anolis* functionally as a palette, in which the different colors are like collapsible tubes set side by side, the tints being produced by pushing the colors against this window of almost membranous tissue, for to such I have likened the transparent vestment. Suppose a mosaic of microscopic discs or hexagons of more colors than one

set side by side, say yellow and blue. The effect would be green, and as perfect to the eye as if these two pigments were mingled on a painter's palette. Thus I think we find a constitution in these two specimens of exuviated lizard skin which stands in physiological relation to the animal's mimetic functions, in *Phrynosoma* as a monochrome and the superficial situation of the pigment, and in *Anolis* as a polychrome with the deeper location of the color cells.

One of my Anoles long outlived the others, getting to know us, and even to take flies from our fingers. We called him Nolie. When awake, especially if he were active, the color was a sombre gray or brown ; but if taking a siesta he would put on a suit of green. In his night sleep this would be often a frosted pea-green, very rich, having a sort of bloom not unlike that of oxidized bronze. The Anoles belong to the family Iguanida, and, like the large Iguanas, they have a fold under the throat, which, though imperceptible for the most part, can be suddenly developed into a dewlap of large size and of flaming color. I have seen Nolie wake from sleep, perhaps from an amatory dream, for he would assume his gayest courting suit, a vivid green, with here and there a tint of orange, and in some places the green would be nearly blue, and that improvised dewlap in blazing scarlet—a cravat perfectly stunning for color and dimensions. Indeed, the suddenness of the development and the intensity of the color were simply remarkable. One day he got out of his cage, and a prolonged search failed to find him. But when the night set in that whitish-green gave him away, it was in such marked contrast with the rung of the black-walnut chair to which, almost flattened out, he was adhering sound asleep. Here certainly mimicry was all at fault. As my hand seized him the green flashed out and the normal brown took its place.

It was well no worse thing happened to our pet, for in the shock of sudden fright these little lizards sometimes dislocate their tails. "This is owing to a thin, unossified, transverse septum which traverses each vertebra," the vertebra breaking easily through this brittle plane. A very near cousin to *Anolis* is our New Jersey Pine Lizard.[1] This pretty little thing will sometimes get on the door sill in the pines, and should the good housewife take the

[1] *Sceloporus undulatus* (Harlan), one of the "Tree Swifts."

broom the little swift darts off, occasionally leaving its tail. I have been assured by an old woman "that it does this so it can run faster, but that if the tail is let alone it will come back at night and put it on again." I once had an *Anolis* get out of a box containing several when I was travelling in a rail car. As it was on the floor of the car, my movements in its capture had to be quick and almost violent. This entailed disaster, for the runaway was returned to his companions minus his tail. In about three months the lost member was replaced by a new one. This curious condition ensued. While all the rest of the body was polychromatic, the tail was a simple monochrome. It could not take on any hue other than its one normal brown. Nature had restored the tail, but she could not duplicate "the true inwardness" of the lost member. The palette of living colors and the muscular system for the collapsible tubes were wanting. The little fellow would go to sleep in his night robe of green, but that tail was always the one sober brown.

The cast-off skin of the *Anolis* is a pure, gauzy white, and to the unaided eye not unlike lace in structure, but in fineness far beyond the possibility of any human fabric. But under the microscope this delicate tissue displays a beautiful complexity of structure. The lattice-work is not so coarse as in *Phrynosoma*, and each window pane seems to be made up of irregular lesser panes, and these with extremely delicate lattices. The panes, too, are very thin and clear, with no pigment granules.

Exuviation is started at the head generally, although I have seen instances where the skin began cracking first in other parts. Having got broken at the head, which presents the appearance of a very ragged and highly starched night cap, the rent proceeds along the neck and back. As the *Anolis* is a lithe and extremely agile creature, it can undress with facility, for its mouth can reach any part of the body and detach the loose skin. It doffs the old suit in a very leisurely way, stopping to swallow each piece as soon as it is detached. Nor does it gulp down the cuticular morsel, but eats it slowly, not unlike the refined epicure who gives his food the sauce of gustatory contemplation. Strange, too—exuviation of the new tail is less facile than was that of the old one.

We have left the *Ophidia*, or serpents, for the last. From the

huge Boas and Pythons down to the little snake met with in a rural walk, each and all without exception shed the skin, and, as a rule, cast it whole if the animal is in a healthy condition. It is observable, too, that these reptiles have no polychrome power whatever. The green snake while in the grass finds its color protective, but the reverse when upon the naked soil or crossing the white lichen patches in the pines. The scales of fishes are distinctly different from the true skin, as our nails differ from our skin. Let us repeat that, as with the reptiles already considered, the scales of serpents are simply thickened dermal tissue, over which is spread the true epiderm or thin scarf skin.

Now, having found in the woods just where its owner left it a good specimen of a cast snake skin, four interesting facts may be observed: (*a*) It is shed entire and in one piece. (*b*) It is untorn, except about the head. (*c*) It is turned inside out, as a long stocking might be. (*d*) And fourthly, even the very eyes have moulted, the thin scarf even in shedding preserving their form perfectly in inverted relief.

As to the way in which serpent exuviation is accomplished, the popular idea, and generally even that of the books, is simply this: "when the moulting time has come the animal draws itself between two objects, anything that will suffice for a purchase, such as sticks and stones, and thus manages to rub off its skin."

To such a notion the simplest reasoning upon common observation must demur. At time of shedding the scarf is very moist, and as frail almost as tissue paper. If a lady could have full-length arm gloves of as thin and frail a tissue, it would be impossible for her maid to remove one by any process of friction or rubbing down without tearing them into fragments. And even if the tissue could resist such treatment, would it be possible that they would thus come off turned completely inside out? Then, as to the serpent's eyes, since they must be moulted too, could such friction do less than injure them? Moreover, the places in which these exuviæ are found are not consonant with this friction hypothesis. For they are quite often found on the plain soil, where there are no objects that could be used for friction; and even the ground where the moult is left hardly shows signs of movement.

Having witnessed the operation in very favorable circum-

stances, I gave an account of it to the *American Naturalist*, January, 1875, and also in *Nature*, November, 1879. The serpent, in fact, is the only creature that can denude itself with the peculiar results which have just been mentioned. The anatomy and physiology of the animal are singularly fitted for the operation. The ophidian eye is immobile. Though the books speak of the serpent's eyelids, it is simply accommodating language, for it has no true eyelid. Citing P. Martin Duncan in substance, the so-called eyelid of the serpent is an immovable covering of three superposed layers. First, there is the outer one, the epiderm, which is moulted; this is elastic, and is the thickest over the middle of the eye, manifestly for protection. Under this is the second or middle membrane, which is very delicate and soft, and at the centre perfectly transparent. Under this is the third layer, a mucous lining. This is functionally the palpebral lubricant. Thus the outer covering of the eye is really a part of the scarf, extending from the snout to the end of the tail.

In an old Boa or Python are over two hundred pairs of ribs. These begin immediately back of the atlas or first vertebra and extend to the beginning of the tail—that is, where the dorsal vertebræ end and the caudal series begins. The abdomen of a snake is covered with transverse parallel scales, or scutes. These, when set on edge and acted upon by the ribs, become a vast mechanism of motor propulsion. For this purpose the ribs are all functional. A pair of serpent's ribs form almost a circle, and can perform a fore and aft movement, and can be operative through the circumference of the body except immediately in the dorsal region. We shall see that the ribs have all to do with the act of exuviation. It is hardly a figure of speech to say, as will be shown, that with his ribs the serpent creeps out of his old clothes.

In the pines of New Jersey is a fine colubrine serpent, the *Pityophis melanoleucus*. I have kept these for years in my study, and will give substantially a paragraph from my article already referred to as in the *American Naturalist*. It describes the exuviation of the Pine Snake as I witnessed it on the floor of my library: When I first saw it I noticed that the skin at the snout was torn, and that denudation had proceeded from the head to some two inches of the neck. The divesting at first glance had a sort of

rolling aspect. What surprised me was the fact that there was not the least friction in the process—that is, there was no rubbing against any object. As the old skin at this time is moist and a little elastic, any swelling of the body stretches and loosens it. So soon as the exuviating reaches the body, where are the larger ribs, the process goes on rapidly and with a singular system. It is done in this way: Exactly at the place where the skin seems to be moving backward a pair of ribs expands. This action swells or enlarges the body at that place, and thus by slightly stretching loosens the skin there. In this movement both ribs in the pair engaged act together—that is, they expand at the same time. This action is instantly followed by a second movement, very different from the first. One rib of the pair, say the one at the right side, slips out of and forward of the constriction just made by the swelling. The advanced rib is then drawn backward with a jerk against the neck of the old skin. The rib then rests, holding this side of the skin backward. The left rib advances, and repeats for its side the action which has taken place on the right side. Thus the action of the ribs, which at first is together, is now alternate. The next hinder pair of ribs now takes up these movements. So close are these consecutive actions, and so rapid, that, while the entire body does not make any perceptible advance on the ground, it seems, at the places where the ribs are acting, to be crawling tremulously out of a double tube.

It is noteworthy that unless the philosophy of the process be considered, whether it be the eating or the undressing of the serpent, the eyes of the observer will be deceived. One smiles at the man who said "he never felt so good as when he had got himself outside a beefsteak." Now, this "getting outside" is a literal fact as respects the serpent with its prey. By a hitching on and pulling upon its victim with each side of the mouth alternately, the body is actually drawn over the prey. So is it with this action of the ribs in exuviation. Apparently it is a pushing the old garment backward, while really it is a pushing or advancing of the body forward. The old hose evolves from itself forward, though it seems to be rolling on itself backward.

Herein is revealed how it is that a serpent is at the finish of an exuviation practically where it was at the beginning of the process. The ribs forward of the pair which is acting on the skin are oc-

cupied, each pair with its own abdominal scute, which has a purchase or hold on the ground; hence the curious fact that, however long a serpent may be, it comes out of its skin without much forward movement of its body. When the tail is reached this peculiar play of the ribs is wanting to act upon the skin. But the caudal tapering makes the shedding easier, as, in fact, the skin can then be shaken off. As the end of the tail of the Pine Snake is a hollow spike, this, for obvious reasons, cannot be turned inside out, so it is left turned inside of the skin, all else being turned inside out.

Truly my *Pityophis*, in its new attire, seemed transformed in beauty, such was the contrast between the old coat and the new in the freshness of color. The white ground had a rich creamy hue, not unlike that which the ladies so admire in antique lace. There was, too, a soft warmth in the brown, the chocolate, and the chestnut. With some serpents the new skin shows a fine iridescence in the light. But this soon gives out, the old skin getting dull and lustreless, for the serpents have no power of color mimicry.

With many others I have not been able to see "the wisdom of the serpent." Still, I think we may claim for it better manners than are found among its reptilian cousins of higher rank, for in the disposition of its cast-off linen no serpent ever mistook the bread-bin for the laundry basket.

A certain eloquence has of late descanted upon "the mistakes of Moses." Might it not be pleasanter to look into the wisdom of this great leader of his race? I can only accept evolution as a method in which the Creator works His will, as when He makes one vessel to honor and another to dishonor. Appearing almost the last of the vertebrates, the serpent comes a limbless, a degraded creature. Hence this Moses struck upon a vast cosmic law which only the biology of to-day could formulate—the evolution of progression and the evolution of retrogression—that in the Creative purpose there is a differentiating backward and a differentiating forward. It surely, then, was retrospective wisdom which said of the serpent: "Doomed above every beast of the field, upon thy belly shalt thou go."

NOTE.—Up to within a few years the physiologies taught that the tadpole's tail, just before the transformation into the frog, was dropped or lost by atrophy. Even yet this idea appears in some natural histories. During the last year I read a description, by a well-

known and elegant writer, of a great number of little toads leaving the water and dropping their tails on the ground! He drew upon his imagination, not his observation. In April, 1861, I contributed to *The Rutgers College Quarterly* a paper, under the title "Crangasides: A Batrachian Biography." In that paper was shown the use of the tail as pabulum to the frog during a few days at the beginning of a critical change in life, this appendage being absorbed into the animal as condensed alimentation.

NERVES AND NERVE ACTION.

BY CARL HEITZMANN, M.D.

(*Read February 3d*, 1893.)

When, twenty years ago, I made the discovery that so-called protoplasm, at that time considered as the living matter, was of a highly complex structure, being traversed by a delicate reticulum, the points of intersection of which were the nucleus and the granules, my assertion met with incredulity and scorn. By and by histologists satisfied themselves that I was right. Even the French now admit the presence of such a reticulum, dubbing it "hyaloplasma." All doubts must vanish upon looking at the photomicrograph published by S. Stricker, of Vienna, in 1890, taken by means of electric light with a power of 2,500 diameters. The photograph, which I here exhibit, is that of a living, or fresh, colorless blood corpuscle of a newt, *Proteus*, from the Adelsberg grotto in Austria. The reticulum is exactly of the appearance which I described and illustrated in 1873. Since I saw the reticulum in continuous movement during the life of a protoplasmic lump, my conclusion was that the reticulum is made up of the living or contractile matter proper; whereas the meshes contained a liquid, as such destitute of properties of life, filling the meshes of the sponge-like structure, and permitting the contraction of the solid portions—*i.e.*, the living matter. The contractions consisted in a narrowing of the meshes, an increase of the size of the points of intersection, the so-called granules, and a shortening of the connecting threads. The extension, on the contrary, proved to be a widening of the meshes, a decrease in the size of the granules, and an elongation of the threads. The protoplasmic lump being ensheathed by an extremely thin layer of the same substance that builds up the reticulum and the meshes, the fluid filling the

meshes could nowhere escape from the protoplasmic lump, but was simply pressed from one portion, when contraction took place. to another portion at rest, causing the distention of the reticulum in the latter part. Should such an extremely thin, expanded flap or pseudopodium find attachment to the slide, a point of fixation is given, toward which the lump is dragged as soon as the contraction ceases and rest is established. On this principle is obtained an easy understanding of the form-changes and locomotions of the *amœba*, as well as of any other living protoplasmic lump.

The question, what living matter really is, no one can answer. Neither can we enter the discussion of the query, What causes its contraction? It is the innate property of the living matter in the lowest plant, as well as in the highly organized human form, that it contracts, thereby causing change of shape and locomotion. The second essential property is that it is able to produce its own kind by taking in food and by generation. The latter feature will not be considered in my address.

When we analyze, with high powers of the microscope, the structures termed "nervous," we come to the conviction that all these structures are made up of living matter in an extremely delicate reticular arrangement. Usually the nervous system is divided into a central portion, the brain, spinal cord, and the sympathetic ganglia; a conducting portion, the nerves proper; and a terminal portion, often consisting of knob- or bud-like formations in the peripheral organs and tissues. Undoubtedly the nervous system is continuous throughout the whole animal organism—in other words, the brain and spinal cord are continuous with all the nerves traversing the body, and these again with the terminal apparatus. Long since the nervous system had been compared with the telegraph, the central stations of which were considered to be the brain and spinal cord, whereas the wires were represented by the nerves. So close is indeed the resemblance that some physiologists have claimed that the nerve action is an electric one—an hypothesis, however, never proven

The brain and spinal cord consist of a gray and a white substance. The white substance is composed altogether of so-called medullated nerves, and is merely a conductive apparatus. The gray substance, on the contrary, is the only central apparatus of

the nerve system. In the gray substance, again, we meet with innumerable protoplasmic bodies, the so-called "ganglion cells," or ganglionic elements, from which, as is to-day generally conceded, arise the nerves proper in the shape of so-called axis cylinders. All these bodies, therefore, are unquestionably central organs. In analyzing the ganglionic bodies we see them composed of a dense, delicate reticulum, first recognized by C. Frommann, of Jena, in 1867. Each ganglionic body sends out a thread-like prolongation, the axis cylinder, and a varying number of branching offshoots, termed, in honor of their discoverer, Dieters' offshoots. All the latter run into the gray substance at large, and only the axis-cylinder offshoot is a nerve, running from the central ganglion uninterruptedly to the periphery of the body. I exhibit such a body with a power of 500 diameters, fully sufficient to recognize the offshoot, though not the central reticulum.

Again, the gray substance is made up of a tiny reticulum of living matter, not quite as dense as that of the ganglionic elements. I was the first to discover this reticulum in perfectly fresh sections of the brain of just killed rabbits, twenty years ago ; but this is an assertion of mine that has not as yet met with the confirmation of other microscopists. The reticulum is easily made visible by a stain with osmic acid, as shown here, with a power not exceeding 300 diameters. This reticulum is connected with all the Dieters' offshoots of the ganglionic elements, and again sends out axis cylinders, the same as do the ganglionic elements. This my assertion has recently found corroboration by Edinger, of Germany.

It is plain that contraction, originating in the ganglionic elements, will be conducted partly to the gray substance by the offshoots of Dieters, and partly to the periphery through the axis-cylinder offshoot, the nerve proper ; for the structure of the latter is reticulated the same as is that of the ganglionic bodies and the gray substance in general.

Many facts, obtained either by experiments on animals or by observations in morbid changes of the brain, have led us to the conviction that the ganglionic elements are the seat of all our knowledge, called positive, brought into our brain from without by the organs of sense. Such a positive knowledge is, for instance, the *a*, *b*, *c* by means of which we read and write, the

1, 2, 3 by means of which we calculate and heap up dollars. Should the ganglion of *a*, in the so-called claustrum, be destroyed by a blood effusion, the capacity of pronouncing or writing an *a* is lost. Should the ganglion of number 3 be destroyed, the idea of number 3, or the capacity of writing it, will be lost. From these facts the inference can be made that the ganglionic bodies are central organs for concrete or positive facts; whereas the gray substance is central for diffuse nerve action, such as fancy, religion, dreaming, fears, hopes, etc. The gray matter of the frontal lobe is the seat of intelligence, as first maintained by Th. Meynert, the regulation of our acts by judgment and adaptation. Hence all mental diseases—disturbances of the intellect—are located in the frontal portion of the brain.

In all nerves running from the central organs to the periphery of the body the most essential and only conducting thread is the central axis cylinder, which is either bare, such as in non-medullated nerves, or supplied with a sheath of nerve fat, or myelin—an insulating substance seen in the medullated nerves, furnishing them with a whitish tint, due to the opacity of the myelin in surface illumination. The axis cylinders, I said, have a delicate reticular structure. Any nerve, though originally medullated, will, upon approaching the surface, lose its myelin coat and split up into a number of extremely delicate so-called axis fibrillæ, best rendered conspicuous by a stain of chloride of gold, introduced into histological technique by the late Jul. Cohnheim, of Germany. All we can recognize on such axis fibrillæ, with the highest powers of the microscope, is a beaded or rosary-like appearance, a series of minute dots, interconnected by the most delicate threads. Evidently this feature is a reticulum transformed into a linear projection of threads and granules, eminently fit for contraction. I exhibit here the cornea of a cat, stained with chloride of gold, showing the axis fibrillæ as they inosculate with the protoplasmic formations, termed cornea corpuscles.

With these facts at hand we may reasonably assert that what we call nerve is a complex reticulum of living matter, either arranged diffusely, as in the gray substance; or condensed into a bulky formation, termed ganglionic element; or arranged in rows, as in the axis cylinders; or in a linear projection, as the axis

fibrillæ. Since contractility is one of the main properties of the living matter, we again must come to the conclusion that the nerve action is altogether due to contraction of living matter. Should the contraction start in the periphery, as, for instance, by a prick with the needle, or a burning match, the contraction is carried centrifugally and results in the sensation of pain. By complex systems of association through the gray substance, the motor centres, which are the largest ganglionic formations, are brought to contraction, which they convey toward the periphery, especially to the muscles, and the result of this centrifugal contraction is motion, either involuntary or reflex motion, or a motion controlled by the gray matter of the brain, mainly its frontal lobes.

While I was publishing my works on protoplasm in 1873 in the Vienna Academy of Sciences, where these views were laid down for the first time, Prof. Th. Eimer, in Germany, published his researches on jelly-fish of the Mediterranean Sea. He succeeded in fixing the minute tissue relations by means of osmic acid. As you see in his illustrations, he claims that in these animals nerves and muscles are continuous formations to such an extent that the beaded axis fibrilla directly changes into striped muscle. This goes far to prove the correctness of my own view. Both nerve and muscle work upon one and the same principle of contraction of the living matter. I have demonstrated the continuity of motor nerves with the sarcous elements of the striped muscle fibres; but the majority of histologists do not as yet admit such a continuity.

In a previous meeting Mr. Hyatt claimed that plants exhibit a certain amount of intelligence and voluntary movement, though they lack both nerve and muscle. My views will easily explain the phenomena. The protoplasm of the plant has a reticular structure exactly the same as that of animals. The reticulum is the living or contractile matter in plants as well as in animals. A contraction, being induced at some peripheral point of the plant, is conducted by the threads of living matter, piercing all cement substances throughout the whole organism, and the motion, so striking in some plants, will result. No intelligence and no voluntary action are needed to perform what the plants do. What we call voluntary action in animals, especially also in

men, is to a great extent only automatic or reflex action. What we do we must do, owing to the contraction of our brain, and so-called will plays a trifling part in controlling our actions, mainly under the guidance of the frontal lobes of the brain.

THE OCCURRENCE OF MARINE DIATOMS IN FRESH WATER.

BY ARTHUR M. EDWARDS, M.D.

(*Read February 17th*, 1893.)

Even the amœba, that formless mass of jelly, begins somewhere and somehow. The diatomaceæ have a beginning, but what that beginning is, and when, and how, is uncertain. But when they began, was it as inhabitants of fresh water, in ponds and rivers, or of salt water, in the ocean? This can be determined with a certain degree of assurance by examining the strata where their silicious loricæ are preserved.

Since I began studying the diatomaceæ, now some forty years ago, their beginning was a subject of constant inquiry, and I think I can now determine with positive certainty that their origin was in fresh-water strata.

The sea, that formed from the falling rain, was fresh, of course, and became salt by the solution of hydrochloric acid and sulphurous acid, and then, further, by the solution of certain salts from the earth. After a time the rain which collected fell as fresh water on the earth and formed ponds, lakes, and rivers. But whether they or the salt sea were formed first is undecided. Fresh-water diatomaceæ formed in some places first, and were carried downward and became brackish and at last salt, as can be proved by examining the strata, as I shall show. At least, such is the inference.

The gathering of which I speak now is from Hatfield Swamp, on the Passaic River, New Jersey. It is about thirty miles above Newark, following the tortuous course of the stream, but only nine miles distant across the country, the Hatchung Mountains, in two ranges, intervening. At Paterson are situated the Passaic Falls, seventy feet in height, and at Little Falls, four and one-half

miles up the stream, an additional fall of fifty feet occurs. Hatfield Swamp is about three and one-half miles long by one and one-half miles broad, and the deposit is clay, about three feet and eight inches deep, where I took the specimens. At Columbia Bridge, four miles further, is a small patch of similar clay, perhaps one hundred feet broad.

Besides the ordinary fresh-water forms, *Navicula* (*Pinnularia*) *viridis* and similar species, there are found two salt-water forms of *Actinocyclus Ralfsii* and *Campylodiscus echeneis*. These are both common in the Hatfield Swamp clay, the *Actinocyclus* as brilliantly colored discs, and the *Campylodiscus* as large, white, saddle-shaped forms. These are also both common on the coast in salt water. And the first is further well known in the guano at Ichaboe, at the Cape of Good Hope. These diatoms cannot be carried up the stream by the tide, as that does not reach higher than ten miles above Newark, some distance below Paterson, and there intervene between the tide and the swamp more than one hundred feet of falls, seventy feet of which are perpendicular at Paterson.

I present some of the clay, and a slide mounted to show the mixture of fresh-water and salt-water forms. Diatoms having originated in fresh water, they may present the same characteristics when transferred to salt water, or they may change totally. How this change goes on has not been determined, but the Hatfield Swamp clay shows that recognized marine forms may live in fresh water, and fresh-water forms have been seen living in the ocean.

PROCEEDINGS.

MEETING OF FEBRUARY 3D, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Forty four persons present.

The Corresponding Secretary presented a donation of diatomaceous material from Mr. K. M. Cunningham, of Mobile, Alabama, with an explanatory communication, dated January 30th, 1893, as follows:

"I forward specimens of a new fossil marine diatomaceous deposit, with the object of putting the find upon record, and of

providing such members as are interested in diatomology with the means of verifying my own study of the same.

"As far back as the year 1878 my attention had been called to the statement made by Prof. J. W. Bailey, in his microscopical observations made in the year 1852, and recorded in the Smithsonian 'Contributions to Knowledge,' that he had detected evidence of marine diatoms in an indurated clay found by him on the shores of Hillsborough Bay, in the vicinity of Tampa, Florida, but from which he had been unable to isolate the diatoms on account of the stony character of the material. Through the intervening years I, from time to time, tried to secure specimens of the material as noted by him, but such specimens as I secured failed to corroborate the fact of diatom contents.

"As a consequence, however, of faith in his statement, I persisted in the hope, and my hopes were realized very recently, as the casual outcome of finding a schooner discharging here a cargo of Florida River pebble phosphates. Examining the composition of the pebble aggregations, I noted the recurrence of flattened, water-worn, and rounded nodules of a clay-like substance, which I found could be easily split into thin layers indefinitely. Applying a hand lens, the clay yielded its secret, as each fractured surface showed innumerable diatomaceous bodies, indicating its marine origin as well as fossil nature.

"The interest in this find is emphasized, as it possibly throws new light on a geological question—*i.e.*, as to whether fossil marine, diatomaceous strata of miocene age could be found on the United States Gulf coast of the same character as those on the Atlantic coast. While the generic assemblage of species does not agree with the Maryland and Virginia miocene diatomaceous clays, the geological horizon may be the same, as the phosphate deposits of the Florida peninsula were laid down upon eocene limestone strata. It is known that the valuable phosphate rock nodules and organic vertebrate remains are embedded in a clay that must be removed by washing, and the presumption is that the clay, whenever this is the case, is of the infusorial or diatomaceous kind.

"The clay material, as sent to the Society, may be conveniently studied in various ways. Split into thin layers and examined by condensed light, analogy will suggest a resemblance to the dia-

tomaceous clays of Richmond, Virginia, in the profusion of discoidal forms covering the surface. These forms, however, are but spectral, as they vanish on wetting. The nodule, rubbed down in water with a brush, will leave a sandy sediment containing sponge spicules, polished sand grains, ovoid amber-like grains, and species of disc forms of the following genera: *Coscinodiscus*, *Actinophtychus*, *Actinocyclus*, *Triceratium*, and minute plates showing a plexus of *Melosira* and *Raphoneis*, the diatoms having been metamorphosed in such manner as to be soluble in nitric or other acids, the same as the organic phosphatized remains of the vertebrates associated with the clay. Finally, the clay may be thoroughly disintegrated by boiling in strong soap solution, and after standing for ten hours it will be reduced to a homogeneous sediment, readily washed and cleaned for examination.

"Concentration of the diatoms from the sand is very difficult, on account of the similarity of the specific gravity of the diatoms and of the sand and other grains associated therewith. Acid treatment, being in this case impracticable, must be avoided. The material is adapted for selected or for strewn mounts. In the latter method a few of the prevailing species may be studied with interest and satisfaction, thereby affording something novel in the marine fossil diatomaceous line of research apparently not heretofore recorded."

Dr. Carl Heitzmann addressed the Society on "Nerves and Nerve Action." This address was illustrated by exhibits, as noted below, and an abstract of the address is published in this number of the JOURNAL, page 66.

OBJECTS EXHIBITED.

1. Diatomacien genus-platte. *Triceratium trinacria*, 280 forms, prepared by E. Thum, Germany: by HENRY C. BENNETT.

2. Mouth-parts of Tapeworm: by L. SCHÖNEY.

3. Photomicrograph of *Navicula crassinervis* (Spencer $\frac{1}{6}$): by H. G. PIFFARD.

4. Motor ganglion of spinal cord of child.

5. Transverse section of gray substance of spinal cord of rabbit.

6. Transverse section of white substance of spinal cord of bear.

7. Cornea of cat, stained with chloride of gold.

Exhibits Nos. 4–7 all by CARL HEITZMANN.

MEETING OF FEBRUARY 17TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Nineteen persons present.

Mr. George H. Blake was elected a resident member of the Society.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, of Mobile, Alabama, dated February 8th, 1893, and accompanying the donation of a slide of selected diatoms from the Florida diatomaceous clay, as follows:

"With the view of placing upon record in a more definite manner the recent find of a fossil marine diatomaceous deposit derived from the phosphate area in the vicinity of Tampa, Florida, and of which I duly forwarded specimens to your Society, I have ma le a further study of the same by microscopical preparations, one of which is sent you herewith, and I would offer as a result of that study the following observations as illustrative of the character of the deposit.

"From a portion of the cleaned material I selected free-hand about seventy perfect and fractional discs, and, upon studying the same in detail with a $\frac{1}{6}$ Zeiss objective, I can state that the surface ornamentation on the various species of *Coscinodiscus* found in the deposit prove to be hexagonal scales, which may be partially or wholly detached from their discoidal bodies, thus leaving smooth surfaces, with or without traces of the striate-punctate places of union of the scales with the frustules. In many cases where the reticulated ornamentation is wanting and the surface of the disc is left smooth, innumerable minute diatoms of various species may be seen, overlying the surface, or possibly forming a part of the internal or histological structure of the shell, during the secretion or growth of the silicious layers of the frustrule during its living state. Were this view to be entertained, it would introduce an element of doubt in the present view

of the diatom being a plant instead of belonging to the infusorial group, as Ehrenberg had at first placed it.

"As tending to prove that the minute diatoms, visible through, or upon, or in the body of the disc, are not casual surface débris of the deposit in which the discs grew, I would mention the following as a very delicate test. In one of the discs on the slide there is a minute *Dictyocha* partly overlapped by a minute diatom of the *Navicula didyma* shape. To view either of these small diatoms distinctly, a material movement of the fine adjustment must be made; for while one is in focus the other is out of focus, thus showing that they are not on the same superficial plane. Again, many of the minute diatoms offer a strong contrast with the transparent disc, as would be the case where diatoms are seen in such a refractive medium as liquid sulphur, in which the diatoms look black by contrast with the enclosing medium; or where mediums are compounded with phosphorus, giving the highest refractive value. If a lens of high power, say a $\frac{1}{12}$ or a $\frac{1}{15}$, is used, these minute diatoms will prove of greater interest than the larger discs with which they are associated. My experience with the new diatom material has given me an entirely novel field of interest and study, which is within the reach of all whose forte is to unravel new truths and evolve new lines of thought in relation to the histology of the diatom.

"In having placed this new source of diatoms on record with the New-York Microscopical Society, we have types of diatomaceous deposits from the three principal geological eras of the tertiary period: the eocene, by the diatoms from St. Stephens, Alabama (tripoli); the miocene, from the Florida phosphate clay; and the pliocene, from the clays encountered at a depth of seven hundred feet in the Mobile artesian wells; not to mention the recent, or living, species surviving through these long periods of sedimentary deposition. In summing up the result of a limited amount of study of this miocene fossil diatomaceous clay, I find the following genera represented: *Craspedodiscus, Coscinodiscus, Actinopticus, Triceratium, Biddulphia, Melosira, Navicula, Raphoneis, Pleurosigma, Synedra, etc.*"

Dr. Arthur Mead Edwards, of Newark, New Jersey, being introduced by the President, addressed the Society on "The Occurrence of Marine Diatoms in Fresh Water." This address

was illustrated by preparations exhibited, as noted below, and is published in this number of the JOURNAL, page 71.

Dr. Edwards also donated to the Cabinet of the Society a packet of the clay of Hatfield Swamp and a prepared slide of diatoms from the same. Dr. Edwards further gave an account of his experience with the use of Gum Thus, from *Pinus tæda* L., as a mounting medium in place of Canada balsam.

On motion the thanks of the Society were tendered Dr. Edwards.

OBJECTS EXHIBITED.

1. Seven slides, containing 1,021 diatoms, prepared by E. Thum, of Germany: by HENRY C. BENNETT.

2. Möller's Probe Platte, 80 diatoms, arranged in lines with names photographed beneath: by CHARLES S. SHULTZ.

3. Diatoms from California: by FRANK D. SKEEL.

4. *Bacillaria paradoxa*, living in aquarium since October, 1892: by STEPHEN HELM.

5. Fossil diatoms from Manatee River, Florida, prepared by K. M. Cunningham: by J. L. ZABRISKIE.

6. Diatoms from Hatfield Swamp, N. J.

7. " " Nutley, N. J.

8. " " South Plainfield, N. J.

9. " " "Kettle Hole," near Plainfield, N. J.

10. " " Columbia Bridge, N. J.

Exhibits Nos. 6–11, all mounted in Gum Thus, prepared and exhibited by DR. ARTHUR MEAD EDWARDS.

MEETING OF MARCH 3D, 1893.

The President. Mr. Charles S. Shultz, in the chair.

Thirty-eight persons present.

The Corresponding Secretary read a communication from Mr. Charles S. Fellows, of Minneapolis, Minnesota, accompanying the donation of a slide of *Terpsinoe musica* to the Cabinet of the Society, and dated February 19th, 1893, as follows:

"I noticed in the JOURNAL a letter, read October 21st, 1892, from Mr. Cunningham, regarding *Terpsinoe musica* Ehr.

"In 1883 I found this form in Florida. A spring took its rise

in a limestone ledge, and on the edge of the crevice, where the water ran through, I scraped off the dark slime and examined it when I arrived home.

"In looking over my slides I found one put up by J. D. Möller, marked '*Terpsinoe musica* Ehr. A. dulce, Porto Rico,' showing that at that date it was known as a fresh-water diatom.

"I find only one slide in my collection, a very poor one, put up by me in 1883, which I forward with this. Your members can compare it with the Cunningham mount. I would like to know if it differs from his."

The Corresponding Secretary also read a communication from Mr. K. M. Cunningham, dated Mobile, Alabama, February 24th, 1893, as follows:

"The information in your favor of the 20th instant suggests, the propriety of my stating upon what ground I reported the diatomaceous clay of miocene age.

"In effect, possibly eight years ago, and also at a later period, Mr. Lewis Woolman, of Overbrook, Pa., member of the Philadelphia Academy of Sciences, opened a correspondence with me to secure my assistance in collecting material to aid his geological inquiries. He intimated that he had a theory which he desired to verify—namely, that the great diatomaceous stratum of 300 feet, more or less, in thickness, studied by him as underlying New Jersey, Maryland, and Virginia, would possibly be found existing on the Gulf coast—and that he had special reasons for holding this theory. After several years nothing confirmed his hopes until I communicated to your Society and to him the occurrence of the polycystinous, diatom, and foraminiferal clay stratum at St. Stephens, Alabama. This fact renewed his hopes, and, while the clay was associated with undoubted eocene strata, it was not what he desired to corroborate his hypothesis. He wanted a clay of miocene age, which the former was not.

"Next I followed the subject through the boring of several artesian wells at Mobile, and sent him the micro-fossil organic evidence of the strata encountered at 700 feet—the foraminifera, and a special minute bivalve whose specific name is still in controversy—indicating that the pyritized marine diatoms found in the clay were of pliocene age. So to this point we had not reached a miocene clay.

"But when I made my last find of Tampa fossil diatomaceous clay, I communicated with Mr. Woolman, and told him that an illustrated article in the *Engineering Magazine* noted that geologists had stated that the productive phosphate area had been 'laid down upon eocene limestone strata, which had not been submerged after the upheaval.' I do not know what construction Mr. Woolman put upon this, but he replied that, if the pebble phosphate was dredged from the Manatee River, Dr. Dall had found distinct miocene fossil shells at Manatee. After he had an actual inspection of the clay, he replied that it struck him as equivalent in age to the Virginia outcrop of miocene clay strata, the same as that which he had studied at Atlantic City and elsewhere, and that he had also consulted Dr. W. H. Dall's latest map of the geology of the Florida peninsula, in which the Fernandina and St. Augustine coast was designated as 'newer miocene,' and the Tampa coast as 'older miocene,' and he proposed making a communication touching the new clay, based on these recently collected data, to the Philadelphia Academy of Sciences as promptly as possible.

"Mr. Woolman had in preparation a paper on a diatom deposit encountered at depths between 90 and 150 feet, in artesian borings at Ponce de Leon Hotel, St. Augustine, Florida, but said that he had not fully settled upon the age of the foraminiferal forms found in his boring samples, and this is why his work has not been put upon record.

"Mr. Woolman was highly gratified at my discovery, as he said that geologists, for two years past, had tried to trace the diatomaceous clay or rock near Tampa on Hillsboro Bay, mentioned by Prof. J. W. Bailey in his microscopical researches about 1852, but without success. He said that he would defer to me, and if I would inform him when my find was put upon record with the New-York Microscopical Society, he would then make his communication to the Philadelphia Academy, giving me full credit for the discovery. So far as he could ascertain, this fossil marine deposit had not been announced by any one previous to myself, although he had been studying diatomaceous and foraminiferal forms from St. Augustine, secured more than a year ago.

"Dr. Edwards wrote me that he thought the clay of eocene tertiary age, and I wrote in reply the material points contained

herein in reference to its being of miocene age. However, if the clay is not of miocene age, it can be so put provisionally until other proof is adduced to the contrary."

OBJECTS EXHIBITED.

1. A substitute for the camera lucida: by H. G. PIFFARD.

2. A microscopical electric illuminator: by H. G. PIFFARD.

3. Arranged spines of *Echinus:* by H. G. PIFFARD.

4. A Zentmayer portable microscope: by WALTER H. MEAD.

5. A simple form of compressor: by WALTER H. MEAD

6. A Tolles micrometer ruling: by GEORGE S. WOOLMAN.

7. A Rogers micrometer ruling; by GEORGE S. WOOLMAN.

8. A home-made dissecting microscope: by F. W. LEGGETT.

9. A Beck microscope lamp: by CHARLES S. SHULTZ.

10. An enlarged model of Smith's vertical illuminator: by CHARLES S. SHULTZ.

11. A metric scale, ruled by Prof. W. A. Rogers on speculum metal, shown by means of the Beck lamp and the vertical illuminator: by CHARLES S. SHULTZ.

12. *Asellus aquaticus*, living: by HENRY C. BENNETT.

13. Sections of spines of *Echinus:* by JAMES WALKER.

14. Automatic revolving stage: by JAMES WALKER.

15. Automatic revolving polariscope: by JAMES WALKER.

Dr. Piffard explained his substitute for the camera lucida—a right-angled prism fitted in place of the eyepiece of the microscope, through which the image is projected downward perpendicularly upon the drawing paper lying upon the table; also his electric illuminator—a cylindrical glass bulb, three inches in length by one inch in diameter, the illuminating filament, of the ordinary horseshoe form, being composed of copper wire, with the exception of three-quarters of an inch in length of the middle portion of one limb of the horseshoe, which portion consists of carbon. This carbon, when incandescent, gives a streak of light of intense brilliance about three-quarters of an inch long and apparently about one-eighth of an inch wide. The magnified image of this, focussed upon the object, gives "critical" illumination. Diffuse illumination is obtained by racking the condenser a little out of focus.

Mr. Mead described his exhibits—a Zentmayer portable micro-

scope, made twenty years ago, of exquisite workmanship, having no fine adjustment, but an excellent coarse adjustment; also a stage compressor of unusually easy operation.

Mr. Leggett described his home-made dissecting microscope, comprising adjustment for the lens, swinging mirror, and firm, ample stage.

President Shultz explained his greatly enlarged model of Smith's vertical illuminator, which he had constructed for the occasion, exhibiting plainly, at one view, to the entire audience the operation of the apparatus.

Mr. William Wales said that, in conjunction with Prof. Hamilton L. Smith and Mr. George Wale, he was engaged during two years in carrying out Prof. Smith's ideas of the vertical illuminator. They made both forms—glass and metal reflectors. The apparatus was patented by Prof. Smith and the patent was assigned to Mr. Wales.

Mr. George S. Woolman corroborated the statement of Mr. Wales, and said the credit of the invention was due our country.

Mr. Shultz stated concerning his exhibited metric scale that Prof. Rogers worked for a year over this admirable scale. It was soon found that speculum metal afforded the best lines, and the most uniform power for actuating the ruling machine was obtained from a weight elevated high in the building containing the machine.

Mr. Walker explained the method of cutting his sections of spines of *Echinus*—the spines were thrust firmly into the holes of ordinary pearl buttons, cemented in place with balsam, cut off close to the buttons with a saw, and then spines and buttons together were ground down to proper thinness on successive stones. Mr. Walker also described his automatic revolving stage and polarizer, actuated by clockwork.

Dr. F. D. Skeel explained with blackboard drawings his improved attachment for moving the fine adjustment of the microscope in photography; the main point of which improvement consisted in carrying the long, endless cord, at the side of the camera, to a grooved pulley on the stand below the fine adjustment, and then coupling this pulley with the grooved milled head of the fine adjustment by means of an additional short, endless

cord. This arrangement gives very easy, uniform motion, and avoids all unequal strain upon the fine adjustment.

Meeting of March 17th, 1893.

The Vice-President, Dr. Edw. G. Love, in the chair.

Twenty-six persons present.

Mr. Frederick Kato was elected a resident member of the Society.

Dr. Arthur Mead Edwards read a paper entitled "On Mounting Objects in Substances of High Refractive Index." Dr. Edwards also donated specimens of Gum Thus to the Cabinet and for distribution.

OBJECTS EXHIBITED.

1. Brass slips for diffusing heat in mounting: by Arthur Mead Edwards.

2. A super-stage for elevating the object above the stage of the microscope, allowing very oblique light from beneath: by Arthur Mead Edwards.

3. Inexpensive slides of diatoms, prepared by P. Klavsen: by Arthur Mead Edwards.

4. Samples of purified Gum Thus, Styrax extracted by xylol, and of Iodide of Methyl: by H. G. Piffard.

5. Diatoms mounted in Styrax: by H. G. Piffard.

6. Human skin undergoing calcification: by H. G. Piffard.

7. *Pleurosigma* Genus Platte, 70 forms, mounted in monobromide of naphthalin: by Henry C. Bennett.

In reply to the question by Dr. F. D. Skeel, "Can diatoms be stained?" Dr. H. G. Piffard replied in the affirmative, referring to the accounts by M. Tempère, of Paris. Dr. Skeel stated that agate can be stained by successive immersions in honey and sulphuric acid, and that many carnelians and agates are thus stained.

Rev. J. L. Zabriskie gave some points of his experience on the ease and rapidity of mounting in glycerin. In case of objects 0.001 of an inch or less in thickness, permanent glycerin

mounts can be made without the employment of any cell. Spin with the turn-table a guide ring of India ink, about one-sixteenth of an inch larger in diameter than the intended cover, upon either the upper or lower surface of the glass slip; place a minute portion of the glycerin—the proper quantity for different sized covers being soon found under a little practice—in the centre of this ring with a rubber bulb "dropper" to avoid bubbles; insert the object in this glycerin by means of needles; lower the cover glass upon the object very slowly; avoid squeezing out the glycerin beyond the cover, using only delicate pressure with the needles, sufficient to cause the fluid to spread to the entire periphery of the cover; seal the mount at once with a solution of brown shellac in alcohol, used as thick as will flow easily, which shellac will form a jelly by union with the glycerin at the edge of the cover, thus preventing the running in of cement subsequently applied; set the mount aside for twelve or twenty-four hours; and then finish with a cement consisting of equal parts of Japan gold size and ordinary asphalt varnish. One coat of this cement will hold for a long time, but it is better to use successive coats, laid on at intervals of twelve or twenty-four hours, until a smooth, bevelled ring covers the edge of the mount.

In the use of a cell of any considerable depth, where it is not so easy to avoid excess of glycerin, after the cover is gently pressed down, apply a spring clip of very moderate force, only sufficient to maintain its own position when the slide is handled; wash away the excess of glycerin by holding the mount slightly inclined under a gentle stream of water, about the diameter of a lead pencil; avoid drawing out the glycerin by attempting to wipe the cover or its joints, but blow away the adhering water with smart puffs of breath; place the mount on the turn-table, with the spring clip still in its position, and seal at once with the shellac solution, and after twelve or twenty-four hours cement with the black mixture as before.

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NOTES ON SOME RESEARCHES AMONG THE DIATOMACEÆ.

BY K. M. CUNNINGHAM.

(Read November 17th, 1893.)

By a peculiar trend of events my attention had recently been called to the question of the plant or animal nature of the diatoms. This question had hitherto been of little interest to me, very nearly all of my interest having been directed merely to an accumulation of specimens of fossil or recent deposits and the study of their distribution. But certain favorable opportunities have enabled me recently to devote some attention to the study of living diatoms. With this object in view I have prepared, and, after due study of the same, I send herewith the series of slides illustrating this paper as a donation to the Society.

It may be of historic interest to recall the fact that in the "Smithsonian Contributions to Knowledge" there is a publication, bearing the date of 1850, and entitled "Microscopical Observations made by J. W. Bailey, of West Point, N. Y., during a tour through the States of South Carolina, Georgia, and Florida," in which work were listed and tabulated all infusorial and other microscopic forms of life encountered in his travels through the said territory, including the diatoms and the desmids, with figures of the new species found by himself. Since the year 1878,

when I became aware of the existence of the publication, its subject has lain as a dream in my mind. Years after, when I had become quite familiar with the diatoms of both the South and the North, I recalled that in his tabulation from all sources he had listed about ninety-four species, including both marine and fresh-water, and never exceeding more than twenty-five species from a given locality. It has also been a matter of curious interest to me as to the methods of preparation for study in vogue in or about 1850. In the present day, as proved by my slides, I have been able to get eighty species in a single mount from Mobile Bay marine muds, and nearly seventy-five species from the brackish material from the shore of Mobile Bay—the same material as apparently examined by him from Mobile Bay. In alluding to this, I do so with full respect for the eminence of the most prominent investigator, in his day, of the diatoms of North America, and not with any desire to detract from the honor of his laborious researches; but the thought calls up the question as to whether the methods of to-day are in advance of those of nearly a half-century ago. In the preparation of this paper I could not well omit the name of Prof. J. W. Bailey, as its interest turns largely upon a diatom described and figured by himself from material derived from Mobile Bay, and shown in the plates to his work referred to above; and likewise shown in Wolle's "Diatomaceæ of North America."

The opening during the present summer of a resort on Mobile Bay, known locally as Monroe Park, by the Electric Railway Company, enabled me to visit a strip of the shore of Mobile Bay a few miles south of the city. While there, and looking around for something of interest microscopically, I came upon a stratum of lignite exposed on the beach at low tide. I repeated my visits to this place to study it geologically. With a desire to trace its extension, I made short excursions somewhat further down the shore line from the Park, especially on occasions when the tide was out in the evening. In this area the bay bottom was covered, so far as the surface was free from the tide, with a species of a moss-like water plant, which condition induced me to test whether this moss-like growth would prove a source of diatoms. I therefore gathered a portion of a plant, and by pressure forced the fluid to fall on a spectacle glass used for such tests in the

field. On drying the glass I examined it, and was rewarded by finding an abundance of diatoms, including a species which I had nearly despaired of ever finding or seeing. This proved to be Bailey's *Amphiprora ornata*, as figured in his "Microscopical Observations, etc., in 1850." During all the previous years of my diatom researches I had desired to find *Amphiprora* of any kind whatever, but apparently in vain. Having my "treasure trove," I secured one full plant with its complement of mud, and it is from this, and a second supply of the clean plants, that I have prepared the series of six slides typical of the original material that Bailey must certainly have examined, as he referred to material often gathered from bogs or on shores where the diatom ooze abounded.

On the very same evening that I secured this moist water plant I spent some hours in its examination, applying myself more particularly to the character of the motion of the living diatoms. It took me but a moment to find on the slide specimens of living *Amphiprora* and *Navicula*. Confining my attention closely to the appearance and structure of *Amphiprora ornata*, I was enabled to observe that, if a bacterium drifted toward it and made contact, it would be held as a prisoner in the full power of the protoplasm covering the diatom externally. As is well known through mounted specimens, as well as figures, *Amphiprora* has delicate, hyaline, and rather broad alate lateral processes. Bacteria and rotifers, once in contact with the peripheral edges of the alæ of the *Amphiprora*, are kept in a constant state of alternate or reciprocal motion from either diametrical extremity. That is to say, the bacterium or o her organism is rapidly transported from the middle constriction to one or other of the extremities of the diatom, all the way, or part of the way, in an alternating manner; when it may, after an interval of detention, be rejected by what appears to be a voluntary impulse of the *Amphiprora* itself. Having seen this phenomenon, I at once became aware of its importance in any discussion involving the plant or animal nature of the diatom, and more particularly as all my previous acquaintance with the Diatomaceæ had permitted me to remain content with the generally accepted opinion that the diatom was "a lowly unicellular plant."

This accidental discovery of the motility of the protoplasmic covering of the *Amphiprora* induced me to see what was already of record in relation to the cause of the directive motion of many genera of the Diatomaceæ, but more particularly the Naviculæ. I forthwith consulted all the available references to the life history of the Diatomaceæ within reach. Neither the "Encyclopædia Britannica," latest (ninth) edition, "The Columbian Cyclopædia" (1892), "Micrographic Dictionary" (1856), "Carpenter on the Microscope" (1856), Rev. Francis Wolle's "Diatomaceæ of North America" (1890), "Generalities, on the Diatomaceæ," of Count Abbé Francesco Castracane (1884), nor the address of ex-President Charles F. Cox before this Society, entitled "What is a Diatom?" and published in full in the JOURNAL (January, 1892), contained the slightest reference to, or a suggestion of the phenomena partially described in the preceding introduction, but most or all of the authorities confined their notice to the distinct and evident motion of translation of the diatom frustule in a simple direct or retrograde motion. The mystery of its motion was left involved in hypotheses, and no satisfactory solution was offered by the various observers. That any diatom had a dual or a subsidiary motion was everywhere regarded in the negative or not entertained at all. The *Amphiprora*, which clearly exhibits this dual power, is not mentioned at all. The fact that *Amphiprora* has some of the attributes of protozoan life, rather than that of plant life, had been hitherto overlooked, or at least seems to not have been specifically alluded to, especially as appears in Wolle's "Diatomaceæ of North America," which presumably should give the highest reach of experimental research obtaining on this subject to the year 1890. In the opinions submitted therein the cause of the motion of diatoms remains a mere hypothesis requiring elucidation. And no authors so far have touched upon the subject of the dual or compound motion exhibited by *Amphiprora ornata* or any other species of *Amphiprora*.

After my initial experience related above, I made a second visit to the bay shore, and carried along a collecting bottle, into which, from a new supply of the peculiar moss-like water plant, I expressed as much fluid from it as I deemed necessary, and at night proceeded to study it *de novo*. By the most delicate manipulation known to me I freed the material from sand, and by repeated

washings in water and by a special form of concentration I secured a dip to examine on an uncovered slide. For a period of three hours I watched the various living and moving diatoms, noticing closely every condition presented by such as appeared, but seeking especially to keep in the field an *Amphiprora ornata*, which is one of the smallest of its genus, but sufficiently large to study clearly. The same phenomena were presented as in the first experiment, but with this variation: after observing a bacterium that had touched the edge of the ala on the left side, it was oscillated a few times alternately, and was then transferred along the edge of the ala to the constriction, and then continuously across the broad central portion of the frustule to the ala on the right side, always along the periphery, and on to the opposite extremity of the diatom, where it disappeared. Immediately after this a good-sized, motionless rotifer drifted into contact with the left ala and was rapidly rotated along the edge of the ala on the left side, and was then carried to the middle constriction, where it was retained some time, when it was rejected by the diatom. While the rotifer was being manipulated on the left side a bacterium was performing its oscillations on the right periphery, and what appeared to be a cluster of bacteria were held prisoners above and around the middle portion near the constriction of the alæ.

Another feature of interest attaching to the motion of *Amphiprora* is that in the event of its being capsized by striking some obstacle in its path of motion, if thrown on its narrowest edge—front view—it at once struggles to regain the position, which displays its side view, and then its motion continues direct and rapid. This action intimates an intelligence akin almost to that of a beetle on its back exerting itself to regain its natural position on its feet.

While shifting the field in order to observe some other indications of the life motions, I observed a simple, small *Navicula* having in contact at one of its sublanceolate ends a *Nitzschia closterium*—closely agreeing with Wolle's figure. The *Navicula* seemed to be rapidly driving the *Nitzschia*, in the manner that a violin bow is rapidly drawn by rising and falling strokes, or in a see-sawing motion, while the *Navicula* was quiescent. This produced the illusion of the source of motion being situated at the prow or apex of the *Navicula*. But a moment later the illusion

was explained by seeing another *Nitzschia closterium*, having attached to its exoplasmic layer foreign particles that were being rapidly transported around its entire periphery, from the right side around to the left, sometimes direct, sometimes alternating. At another time I saw a small rotifer held a prisoner by a small *Navicula*. At times the rotifer moved away a space equal to its diameter, but was drawn back each time into a fresh contact with the edge of the diatom, as if by some invisible force. While still in contact with the *Navicula*, it drifted or was drawn between the *Navicula* and an *Amphiprora* into a sort of cul-de-sac. I saw also that under this mysterious force it vibrated rapidly between the two diatoms—the rotifer, being inert, had not an independent power of motion to release itself from its captors. In the drop of water on the slide there were numerous and very active small *Naviculæ*, whose motions presented nothing of special interest, except possibly that they often came in contact with larger *Naviculæ* and passed by in contact with the protoplasmic sheath of the larger diatoms, and soon parted company with them, as their motion was swifter and not retarded by the sliding contact. This will suffice to record such observations as were derived from a painstaking study of material taken from the shore of Mobile Bay and examined within an interval of six hours.

Desiring to gather additional data bearing upon the behavior of the living diatom under the lens, I had, about a week previously, secured some fresh-water diatoms directly from a natural spring at the village of Whistler, Ala., five miles north of Mobile. On a visit to the same locality in March last I casually found a beautiful, clear spring flowing from a grassy, sloping hillside into a barrel sunk flush with the grassy surface of the adjacent ground. Selecting a small sample of the algæ through which the spring flowed away, I expressed the fluid therefrom on a spectacle glass, and examined it with a pocket lens. I was surprised to find the glass surface covered with a pure gathering of *Navicula viridis*, all united in fours, or what I would call "tetradelphia." I then collected in a bottle a portion of the material and took it to Mobile for examination as to the number and association of species. But too much extraneous matter prevented a suitable slide from being prepared, and the beautiful phenomenon of the spectacle glass could not be repeated. On a recent

visit to the same spring, in the early part of September, I took with me a one-ounce bottle with parallel sides and semi-cylindrical ends, which form was useful in the subsequent observations. Having in mind the subject of the motility of the brackish-water diatoms of Mobile Bay, I desired to pursue the subject further with a distinctly fresh-water variety of diatoms. The material expressed from the algæ of this spring I studied for five consecutive days.

On the evening of the day that I secured the Whistler material I prepared a portion for examination, by repeated washings, settlings, and changes of water, and then placed a drop on a slide, when I found an abundance of living *Navicula viridis*—single large individuals, and shorter ones grouped in fours and adherent to each other. The first fact verified was that during the interval between March and September the diatoms were still largely represented by the fourfold combination seen on my first visit to the spring in March.

The following is a résumé of what I observed during a close study of the living material. On the first night of my study I sought to detect, if possible, the presence of the protoplasmic mantle or sheath as demonstrated and observed by Cornelius Onderdonk, and recounted by him in *The Microscope* (1890). Having the living diatoms at hand, I made a concentration and removed as much water as possible in order not to weaken the dye. I also had convenient a bottle of aniline violet ink to use in the attempt to differentiate the protoplasmic mantle as indicated by Onderdonk. On adding a few drops of the aniline dye to the living frustules, I quickly placed a drop of the diatoms on the slide and covered the same with a three-quarter inch cover glass. My surprise was great when I observed that the diatoms had been instantly killed by the liquid. All that portion of the field not occupied by the diatoms or débris gave no color indication. After a fruitless search for any indication of an evident protoplasmic layer, I came to the conclusion that it was of such exceeding tenuity that it did not extend sufficiently far from the silicious frustule to indicate its presence at all. But the dye took at once on the diatoms, and on every other particle of matter, vegetable or otherwise. The only inference I drew from this experiment was that the aniline paralyzed instantaneously the

life function of whatever protoplasmic coating that might have previously given rise to the power of locomotion in the frustules.

It then occurred to me to test the effect of the aniline as a means of differentiating the diatoms, the strong and robust, as well as the hyaline forms, which are sometimes nearly lost to view in balsam mounts. For this purpose I allowed a liberal amount of the material to remain in a concentrated solution of aniline for a period of five hours, when I washed them repeatedly in changes of water until no more color was evident in the fluid removed. The result of this staining has furnished me with a wide range of interesting data, fairly recorded in a mount forming a part of the whole series of slides made to accompany these notes. Notably among the phenomena presented may be mentioned that on the slide may be seen numerous large, solitary specimens of *Navicula viridis*, and specimens of a smaller size of the same grouped mostly in fours, adherent together, and others by twos alone. In addition to these there are many specimens of *Eunotia*, *Fragillaria*, *Navicula radiosa*, and other smaller forms, all showing an elegant amethystine color by daylight and a reddish violet by student's-lamp light, and demonstrating that the stain had taken satisfactorily. This staining with aniline violet differentiated certain structures that would not have been modified in balsam mounts. The living diatoms, dried on the slide and covered with balsam, present the endochrome in a uniform layer of color, filling the whole internal part of the frustule, in the various shades of green, olive green, or brownish hues. Whereas, with the aniline stain, the endoplasm has been rent asunder and driven to the side walls of the frustule, and is there densely stained and banked up against the separating walls of the quadruple-grouped diatoms, there being a distinct hyaline or clear line of silex separating the frustules where in contact, thus differentiating separately the collapsed endoplasm of each separate frustule. This action of the aniline on the larger frustules was identical for all. But on the smaller forms the endochrome is merely indicated by two central patches highly stained, with a clear bisecting line of silica separating the two masses of endochrome, the sides of the frustules also showing hyaline borders internally. I said above that there was no appreciable thickness of the layer of exoplasm on the frustules, yet it is evident, by the

frustules taking the stain in such a dense and beautiful manner, that there must have been an infinitely thin layer of protoplasm, which appropriated the dye. My reason for this conception is, that in the two slides of the Montgomery, Ala., fossil fresh-water earth, which also form a part of the series of slides, the silica, no longer having any plasmic coating, refused to take the aniline dye, except in a manner to be referred to further on, the plain surfaces separating the lines of ribs being almost devoid of any show of stain. The above is about all of interest that I could determine as to the effect of an aniline dye on the living frustules.

The bottles containing the living diatoms from Whistler, as well as the fresh brackish-water material from Mobile Bay, were allowed to remain over-night on the mantel near the window. On the next morning I observed the contents of the two bottles with a band lens, and noted that hundreds of the Whistler diatoms had left the sediment and algæ at the bottom, and were travelling around near the line of the surface of the water in the bottle in preference to any other part of the sides. At this moment I recalled the common statement that diatoms, as well as desmids, will congregate at the lighted side of the vessel holding the mud with which they are mingled. To verify this I successfully used the following expedient: Thrusting the bottle previously described tightly down into a parlor match-box, I cut a hole in the paper of the box, a quarter of an inch in diameter, at a point about the middle height of the fluid, and on the reverse side I cut a similar hole, taking care not to detach the pieces of paper, so that they might be opened and shut as little windows, so as to admit transmitted light through the fluid on subsequent examinations. Having done this, I excluded all light from every part of the bottle, except from the central quarter of an inch hole. When this was done I exposed the bottle to the diffused light of the day, toward the south, and at convenient intervals during the daylight, for the balance of the day, I observed such changes as went on at the orifice admitting daylight.

The first phenomenon of interest, after about one hour's exposure, at about 9:30 A.M., was that the diatoms had already congregated at the spot of clear glass in fair numbers and were travelling across the field in all directions, with an easy, steady, direct motion. There were also groups of the "tetradelphia"

N. viridis, and the single larger *N. viridis* was seen. But the most unexpected thing noted was that seven Cyclops and Cypris, and the young of the former, had gathered at the light spot. In a moment the Cyclops scattered, but the Cypris kept on its lively feeding and remained constantly within the spot admitting the light. At other intervals during the day the Cyclops could always be seen playing around or darting across the light spot, and early in the day a few desmids appeared attached to little strands of algæ, and also a few large desmids—*Micrasterias rotata* and *Closterium moniliforme*.

At a time when the diatoms were noted as being quite abundant, I arranged the microscope by bringing the tube to a horizontal position, and placed the bottle upright between the thin metal stage and the substage. I then was enabled to observe the travelling motion of all the diatoms congregated within the radius of the quarter of an inch circular opening admitting the light directly through the centre of the liquid. A Beck & Smith half-inch lens gave a sufficient magnification, of, say, two hundred diameters, enabling me to view all of the diatoms, large or small, while in active motion. This method of examination has the advantage that the diatom is in actual contact with, and is adherent to, a smooth glass surface, and, as its movement progresses in a straight line for the whole distance of a quarter of an inch, the rate of movement can be timed by a watch. As this was relatively slow, it will be needless to state how many seconds were consumed in traversing the width of the opening. And as there were quite a number simultaneously crossing, there seemed to be no interruption to a continuous direct motion, as would happen when a slide is examined in a horizontal position and the field littered with particles of débris. When such is the case the direct motion is usually interrupted. An obstacle intercepting the path of the diatom causes it to reverse its propelling power, whatever that may be. But in the bottle there was no débris adhering to the sides, and the only obstacles to be encountered were other diatoms travelling at will in the general field. The desmids were never adherent to the glass, for if the bottle was held in the hand on any occasion they were always in a tremulous state, chiefly attached to minute threads of algæ, while the diatoms kept up a constant motion, always in contact

with the glass, while being examined with a moderately high-power hand lens.

This movement of the diatoms in contact with the smooth interior surface of the glass bottle will, I think, not yield to any other interpretation, except that the gelatinous character of the enveloping protoplasm permitted them to adhere safely to the glass without impeding their motion at pleasure ; and this is probably why there was little or no evidence of the jerky or retrograde motion often seen in a restricted field, as would appear under a one-sixth lens.

The facts developed here, and in the preceding account of the motility of *Amphiprora ornata*, I propose to utilize in the closing portion of these notes, when I will present my argument in favor of the plea that the diatom has as much right to be regarded as a protozoan as any of the other already acknowledged rhizopods. I return for the moment to note additional studies of the character of the motion of the large *N. viridis*. While contemplating the movements of a large specimen, I kept the diatom constantly in the field to test even a suspicion of any sheath or protoplasm covering. Noting very closely its perimeter, I was able to distinctly make out that the diatom was surrounded by a barely perceptible aureole, its outline being indicated by a row of three or four minute particles of débris—not bacteria. These remained continually at a permanent line close to one edge of the frustule, leaving a hyaline space separating them from actual contact with what would be regarded as the silicious edge of the frustule. While still keeping my attention fixed steadily on this line of minute débris, additional particles were gathered and took their position in line with the others. But for this phenomenon it would have been practically impossible to differentiate the extension of the gelatinous and pellucid covering from the surrounding water.

On another occasion I watched the action of drifting bacteria and other particles passed during the transit of the diatom. These were constantly drifting by, either above or under the frustule. Eventually the progress of the diatom was stopped for a few moments by collision with a mat of débris, when a large, motionless, gelatinous globule was arrested at its free extremity. At the moment I recognized that the globule was under and in

contact with the diatom, and about half-way freed from its end. Now, while the diatom was at rest, the globule, without any motion of its own, was transported back to a point under the central nodule of the diatom. After resting there a moment it was carried back to the free end of the diatom. Meanwhile the diatom freed itself from the obstruction, and the globule was liberated, and I then again saw that the globule was inert and incapable of motion of its own. Therefore it is reasonable to suppose that its motion was due to a propelling influence exerted over it by the exoplasm of the *Navicula viridis*.

With regard to the momentum of the diatom in motion, I saw a rapid traveller, a small *Navicula radiosa*, forge along and strike a large, quiet *N. viridis* about the middle, with such an impetus as to throw the *N. viridis* through an arc of more than forty-five degrees to the left of the point of impact It immediately regressed after the shock. The mathematical physicist could tell the nature of the impact—as impact is a resultant of weight and velocity, and motion is the opposite of inertia, one indicates life and action, the other inability to change position without some extraneous force.

Still drawing upon my study of the Whistler fresh-water gathering, I examined closely the behavior of the "tetradelphia" groups of Naviculæ. I observed that the quadruple brotherhood of so-called single cells could turn around in their own length, that they could also travel in straight lines, and that if capsized or thrown on their "beam ends" they struggled to bring themselves to the normal position of bodies swimming horizontally. While they were struggling to regain the plane of flotation I was enabled to study them in every aspect. In these frustules the characteristic endoplasm, endochrome, oil globules, vacuoles, etc., were clearly seen, more particularly through the cingula, or connecting band, as this is less lined than the frustular faces. This combination of four frustules would seem to suggest that the directive force of the quadruple frustules is controlled largely by the two external frustules, and for the four to move in a direct line the protoplasmic, propelling force (?) must be synchronous in all four; and when it is not so, or when the quadruple frustules are moving in a circle of their own length, the rapid, undulatory vibrations of the protoplasmic sheath of the two

outer frustules must certainly operate inversely to each other, or are not, at least, synchronous and impulsing in the same direction. This is merely suggested as an hypothesis of cause of motion.

As expanding further the subject of motion in the diatom, I will offer another phase that may have a useful bearing on certain of such hypotheses long in print and subject to revision. At another time, while seeking clues to the presence of the protoplasmic covering, I followed a large *Navicula viridis* in its movements through the water, as seen in the field of the microscope, the slide being uncovered. In the wake of the retreating end of the diatom there appeared to be a form of attractive suction over minute particles along its line of transit. A train of minute particles lagged along after the passage of the diatom, at a distance to the rear of about the width of the diatom, until the attracting power had ceased to act, when they would become still. The particles were drawn in semicircular arcs from either side of the axial line of the diatom's passing range, the axial line being tangential to the opposing arcs of motion of the particles following in the wake of the diatom. It would have been impossible for this movement of particles to have taken place if the motion of the diatom was caused by the expulsion, at any time, of infinitesimal jets of water. Likewise it offers an insuperable objection to the theory of motion accredited to Prof. Hamilton L. Smith and quoted from Wolle's "Diatomaceæ of North America": "that the motion of the Naviculæ is due to injection and expulsion of water, and that those currents are caused by different tension of the membranous sac in the two halves of the frustule," etc. Wolle also quotes Cornelius Onderdonk as ascribing the movements of diatoms to "a thin fluid mass in rhythmical motion," which Onderdonk had elsewhere proved to his own mind by experimental dyeing tests: "The fluid rhythmical mass covered the surface of the diatoms." I looked up the original communication of Onderdonk and read it. While his experiments were very interesting, he had made no reference whatever to the power of the protoplasmic layer to capture and tenaciously hold and transport, at its own volition, appreciable masses of living particles.

It may not be inappropriate to introduce herein a transcript of

Rev. W. Smith's views in regard to the motion of diatoms, quoted in Carpenter, edition of 1856: "Among the hundreds of species which I have examined in every stage of growth and phase of movement, aided by glasses which have never been surpassed for clearness and definition, I have never been able to detect any semblance of a motile organ, nor have I, by coloring the fluid by carmine or indigo, been able to detect in the colored particles surrounding the diatom those rotary movements which indicate in the various species of animalcules the presence of cilia" ("Synopsis of British Diatomaceæ," Introduction, p. xxiv.). This quotation would also seem to indicate that the Rev. W. Smith was not acquainted with the peripheral motion of the protoplasmic layer of *Amphiprora*, for if he had been acquainted with this he would have had to modify the above opinion and substitute a form of motility independent of any easily seen ciliary processes.

The theory which the sum total of my experience so far suggests is that the motion is probably caused by an infinitely rapid undulatory motion of the protoplasmic sheath, which I assume to exist, covering the diatom on all sides, which vibratory pulsations are too minute to be seen under any degree of magnification, and whose reactionary beats against the water cause the forward or retrograde movements at the instinctive will of the diatom.

Returning to the theory of propulsion advanced by Prof. H. L. Smith, and with all due regard for his long and signal experience in the study of living and other diatoms, I would respectfully call attention to some points calculated to weaken, or even vitiate, the claims of any expulsive action connected with a median diaphragm separating any two frustules that are united and in motion. The quadruple frustules are fairly quick in their progression. Were the hypothesis actually true for a single individual, we would, in the quadruple instance, have four frustules propelled by two exterior sides, and eight opposing prows, leaving the three central enclosed walls in "innocuous desuetude" until each frustule was allowed to shift for itself.

Before finally disposing of the question of motion of diatoms, I would like to advance two more points of interest bearing strongly upon the subject. In the brackish material containing *Amphiprora ornata* there were numerous specimens of *Navicula Smithii*. I gave some attention to one of these, and if the rela-

tively slow motion of a *N. viridis* can interest and hold the attention, this interesting form must in a higher degree give cause for admiration. Conceive a beautiful, strongly lined, golden-hued oval rushing through the water with a speed outdistancing all other forms that I have ever seen in motion. When this is seen it is almost impossible to disassociate the idea of a strongly pulsating life and animal energy from this little creature. To call it a "simple lowly plant" would be to treat it with a presumptive indignity. If one were permitted to speculate as to the character of its motion, the mind might conceive of vibratile pulsations as swift as the undulatory waves of light, or as the rapid alternations of the electric arc current in producing its light, if we take into consideration the diatom's minute size and its energetic progress through the water by the imagined pulsations of its invisible protoplasmic sheath.

Lastly, in relation to another character of motion—that of the *Bacillaria paradoxa*. When we have seen that the ribbon of conjugate frustules is brought to a straight line with terminal frustules, taking the order of "right dress," and that suddenly the end file leader darts off at a rapid stroke to the end of its neighbor, and that the others do the same in quick succession, until the whole line or group have passed each other, and then repeat the same movements in a retrograde manner, we have viewed a life movement of the most curious interest and truly paradoxical in its nature. If we carefully analyze the consequences of these successive phases of motion, we are forced to admit that each frustule has a sheath of a colloid or gelatinous character (somewhat like the coleoderma of De Brebisson) that allows the contiguous sides of each frustule to coalesce or anastomose and separate with equal facility. If this were not the case they could not live in collective communities. These facts substantiate, without staining or other experimental expedients, the truth that this diatom, and possibly all diatoms, are invested with a protoplasmic mantle imbued with life, and capable of being paralyzed or killed instantaneously by staining agents, and that this protoplasm has some of the characteristics of the protoplasm of the protozoa.

In the brackish material I witnessed a small *Amphora*, quiet and motionless, upon the flat surface of which a bacterium seemed to

be struggling to cross its body, being apparently held by the resistance offered by the protoplasmic layer of the *Amphora*. It is well known by those who have made a study of the simple *Bacillus leptothrix buccalis* of the teeth, that if these are taken directly from the teeth and put in a small drop of violet ink, and a cover glass placed over them, their power to travel will be evident. They move along in a kind of scintillating way, and change their position moderately fast while being observed, so that there is no need of mistaking a bacterial movement for what is known as the Brownian movement of powdered or finely divided inert or mineral particles. The bacterial movement has a distinct and peculiar character. The bacterial form alluded to as traversing the surface of the little *Amphora* was evidently under the restraining influence of a power lodged in the external covering of the *Amphora*. I did not, however, follow it until it freed itself from the *Amphora*. I may remark that this closes an interesting variety of experimental and ocular evidence bearing on the character of motion in the diatom, and also of its protoplasmic surface.

Resuming the thread of my study of the diatoms in the bottle of material from Whistler, Ala., late in the evening of the fifth day of my experimental studies, giving the final examination to the condition of the diatoms at the spot admitting daylight, I was surprised to find that during the interval since I had last examined it exactly fifty desmids had come up and fixed themselves in the illuminated area of one-quarter inch diameter. These were all of one species—*Micrasterias rotata*. The diatoms still had life. But on the next morning—the sixth day—I found that all of the desmids had dropped back into the sediment and were no longer visible, and that the diatoms were all dead and glued to the sides of the bottle by what I took to be colonies of bacteria or some fungoid matter. A new class of life had usurped the territory in continuing the struggle for existence. Collaterally with the living Whistler diatoms, I studied occasionally the bottle containing the Mobile Bay brackish-water diatoms, and I incidentally observed that the rhizopod, *Arcella vulgaris*, was quite common on the sides of the bottle. From the same source I studied the movement of the living pseudopodia of *Difflugia pyriformis*. I was previously familiar with *Amœba proteus*,

but what struck me with most interest during a portion of the time was the presence of beautiful vorticellæ in the sediment at the bottom angles of the bottle. Above the sediment there appeared to be a silvery cloud of monad-like infusoria; and while viewing the vorticellæ with a powerful compound hand lens, the bottle being vertical, I observed that the coronal cilia of the vorticellæ, when expanded and revolving, produced a sort of whirlpool, into which poured a funnel-shaped stream of the minute infusoria. The vorticellæ were attached to débris, and were constantly whirling their cilia and retracting their soft, elongated body. The exuviæ of dying infusoria or bacteria, even from the first day of securing the brackish-water specimens, were rapidly covering everything with a flocculent, ochreous pellicle, which accumulated so rapidly that on the fifth day all the vorticellæ were dead.

The cause of motion in the Diatomaceæ has eluded, so far, a direct and positive solution, and the endosmotic and exosmotic theory seems to be the most favorable hypothesis in the case. The idea of exosmose and endosmose action would occur spontaneously to any one studying the biological functions of the diatom. That there is, and can be, endosmotic action is demonstrated by mounting the dried frustules with thin balsam. The larger *Pinnulariæ* of the Mobile Bay brackish source have the major part of the air within the frustules replaced in a few minutes with the balsam; and this action of displacement of air continues for days after the slide is prepared. This is proved by the so-called canaliculi showing very clearly and distinctly the rib-like markings filled with air bubbles. (That these spaces are not canaliculi, but rather corrugations or flutings, I will endeavor to sustain when I reach the subject of my experiments in charging the markings of the diatoms with coloring matter.) Gradually, after days, there is a full and complete expulsion of all air from the frustules, provided the balsam is thin when first used. If the balsam is quite thick, and dries readily, the air will remain permanently.

In regard to the substances designated as endochrome, chlorophyll, and a substance, derived from the chlorophyllaceous matter of the diatom, known as phycozantina, I have thought it proper to suggest that the contents of diatoms are not identical with the chlorophyll of the desmids or of the leaves of plants, but

are characteristic products of the feeding of the living diatoms among the water plants, or other sources of food supply peculiar to their habitat. I would advance the following, bearing upon the subject, viz.: If the diatoms are expressed from the common green algæ of springs, or slimy confervæ of ditches where the plants are exclusively green, the endochrome is mostly of a dull or bright green, and even emerald green. But the student of the Diatomaceæ is also, almost always, taught to seek for them wherever moist surfaces are covered with a rusty or ochreous color. It is certain that a brown or ochreous color is not indicative of chlorophyll, as the name itself means the "green of a leaf." On the contrary, the contents of the living diatoms derived from brackish mud are mostly brown, or possibly olive brown. While one is contemplating diatoms containing brownish contents, he will also note that the associated vegetable débris in various stages of decay is also brown and matches with the color of the endochrome. So, then, the color of the endochrome is probably a result of the character of the food supply found in the local habitat of the diatom, and it may be a product of morphological assimilation and digestion. On examining certain species of *Surirella* on the Mobile Bay slides, emerald-green stains may be seen at the wedge-shaped end of the frustule, while the balance of the frustule is colorless; but the slides also illustrate brown- or green-colored contents of various shades in extreme profusion.

Having, to my own personal satisfaction, witnessed the indisputable evidence of an intelligence in three representative species of three genera of the Diatomaceæ, and having stated in plain terms the manner in which the proof was adduced, and which is duly capable of verification by any one who will take the trouble to review and corroborate the facts and phases established by my experiments, I will now endeavor to make an expansion of these biological phenomena, to draw attention to the fact that any diatomist, expert or amateur, who sees fit to regard the diatoms as belonging to the protozoa rather than to the unicellular plants, can feel some satisfaction in his own mind, notwithstanding all that is upon record excluding the diatoms from the lowest order of the animal kingdom. This inclination with me has been the outcome of accumulated experience in the study of the

Diatomaceæ, as a purely scientific pursuit or pastime, for the past fifteen years. If the aggregate result of one's efforts in any line of study is of any value, it certainly entitles him to enter the field of generalization, if he finds a reasonable or substantial basis to induce such action.

To within about a year ago I felt satisfied with the commonly conceded position of the Diatomaceæ among the unicellular algæ, and assigned them to the vegetable kingdom in preference to the animal kingdom. Less than a year ago Dr. Arthur Mead Edwards, in a letter to me, propounded the query, "What is a diatom?" and also answered his own question by saying, "I believe that the Diatomaceæ are the Protista." Through an impolitic impulse I replied that it would scarcely be possible to admit that the diatoms were other than "unicellular plants." When, in order to substantiate his conception of their animal characters, he announced in a microscopical journal that he had actually seen the animal occupant of a frustule of *Coletonema eximium* leave and re-enter its shell on several occasions, I wrote him that the species of that name were so small that it would seem hopeless to take that view of one of the smallest among the genus *Pleurosigma*. When we mention the name of this eminent physician, who has devoted forty years of his life to the study of the Diatomaceæ, and who might justly be styled the Nestor of American diatomists, he must be credited with valid reasons for refusing to accept the diatoms as single-celled plants, and for using his abilities in opposition to the continuance of such a view.

I would feel better satisfied to have the station of the Diatomaceæ removed from the domain of doubt which surrounds their position, by irrefragable proof. I would be more contented in realizing that this special class of animated matter was ranged with animal life rather than with plant life. It would tone down and remove from the realm of triviality the enthusiasm of those whose mind has become captivated with the beauty and mystery attached by the Creator to this mystical unit of the universe. If genius could demonstrate beyond cavil the animal nature of the Diatomaceæ, then one would find the objects of his favorite study placed a scale higher than the simple Amœba and in near relation to the beautiful Radiolaria. Who will undertake to explain why the Diatomaceæ so strongly appeal to intellectual

minds? Upon what common grounds of interest have clergymen of all denominations, soldiers, physicians of the cultured races, and many others who were gifted with the naturalistic instinct, been incited to connect their names and fame with a perpetuation of the study of this department of invisible nature, if not through that natural bent which impels the intellectual faculty in certain individuals to an eternal expansion of the philosophical spirit or the conquest of abstraction over matter, space, and time?

Passing to the staining of living diatoms, I will refer to some results accomplished by a few experiments. Having already tried the diatoms derived from a fresh-water spring, I thought proper to extend the process to some fossil fresh-water deposits, on account of their richness and the large size of the contained species. I selected for trial an ounce or two of the fossil fresh-water deposit, discovered by myself two years ago, occurring at Montgomery, Ala., being the most conspicuous deposit of fresh-water forms found in the Southern States.

This deposit contains the largest and most beautiful variety of *Pinnularia nobilis*, whose form was not yet known up to the date of publication of Rev. Francis Wolle's "Diatomaceæ of North America," and, therefore, is not shown in that volume. While employed as draughtsman of the machine shops of the Mobile & Ohio Railroad Company at Whistler, Ala., five miles distant from Mobile, I daily made an extensive use of chemicals in preparing paper for the "blue copying process." I was prompted to use the bath of this process for staining the diatoms. The proportions are these: To an ounce each of red ferriprussiate of potassium and ferrocitrate of ammonia add four ounces of water. The two ounces of diatomaceous earth were boiled in a strong soap solution for an hour or more. Then the boiled diatoms were washed in repeated changes of water to remove objectionable débris and traces of alkali—as the alkalies discharge the blue color of the stain. The diatoms were then freed of water, and decanted on a piece of common blotting paper to remove the remaining water. In this state they were transferred to the "blue process" liquid. The material, in small quantities, was poured on common china plates, and constantly moved about until the liquid and diatoms were spread as a thin layer over the whole surface of the plates, and then exposed to the direct rays

of the bright sunlight for a quarter of an hour or longer. When the rays of the sun had acted sufficiently upon and had thoroughly dried the diatoms, the next step was to recover them by washing the material in pure water and collecting the residuum together again. The experiment proved successful, and the diatoms were seen to be duly stained a beautiful light shade of blue.

I next mounted a slide in balsam and viewed it under the microscope, and was well pleased with the result. The internal corrugations held the stain, differentiating the various markings in a moderately satisfactory manner, and gave the frustules a far better appearance than when unstained. But, not being fully satisfied with the effects of the blue stain, it occurred to me to restain a portion of the material already stained blue. Before having accomplished the blue staining I feared that it would be a failure, and thought to substitute aniline violet for the blue liquid. Taking a pipette, I deposited a quantity of aniline into the blue liquid containing the diatoms, when I observed that the liquids would not mix, but the aniline at once gathered in round drops. Failing in this, I drew off all the blue staining fluid from the diatoms and removed the moisture by decanting again on blotting paper. I next put the diatomaceous mass into pure aniline, and allowed it to be immersed for about five minutes or more. I then removed the excess of aniline dye, and washed the diatoms in repeated changes of pure water until no more stain came off in the water. I then dried the stained material and mounted a slide in balsam. When I submitted the violet-stained diatom slide to microscopic inspection I was pleased at my success, as there was in many frustules a perfect differentiation of all markings of every character; the punctate striæ of *Cymbella*, the pinnulæ of all the *Pinnulariæ*, and the ribs of *Surirella*, were, in many cases, so perfect that every individual rib could be easily counted, the markings called canaliculi, or costæ, having the appearance of a dark, short line with distinct semicircular ends, each perfectly differentiated from its neighboring rib by a delicate, clear line of silex showing no stain ; nor was the median smooth surface, divided by the raphe, stained, but the lines of the raphe and its terminal dots were filled with color.

I offer this as my view of the staining : The internal chemi-

cal deposit of the blue stain had thrown down or coagulated the aniline wherever the blue stain had taken effect. Otherwise, where there were no markings visible on the frustules, as on the smooth median surface divided by the lines of the raphe, there was no stain worth noticing. The raphe was in many cases well differentiated, as well as the two central nodular and two terminal dots of the larger *Pinnulariæ*. These two stained slides were the only ones made to test the possibilities and advantages to be derived from staining. As they have given admirable results, it adds another kind of interest in the study of diatoms. Had the material in the siides containing *Amphiprora ornata* been stained either blue or violet, the *Amphiprora* therein could have been readily located on the slides, but in the undyed state they are extremely hyaline and somewhat difficult to locate in balsam mounts under high powers.

The two stained slides were prepared for the series illustrating these notes. In connection with these two slides it may be noted that there is little affinity on the superficial surface of the fossil diatoms for the dye, but the external surface of living diatoms, after drying and mounting, indicates that such surfaces absorb and retain a perceptible amount of dye, which fact suggests that the external layer of protoplasm must have retained it. On an examination of the frustules in the slide stained by the compound process, it will be noted that there is an indication of coagula of the dye adherent to the frustules, while this appearance is entirely wanting in the Whistler fresh-water living diatoms as stained with aniline alone, and in the blue-stained fossil diatoms from Montgomery, Ala.

If my language has been clear, it will be understood that the salient feature of this article is that the diatom is endowed (possibly all diatoms) with two non-interfering motions, qualities indicative of life—namely, the direct and retrograde, which is the generally known and universally acknowledged motion of the whole frustule, single, double, or quadruple, and also the subjective motility of the exoplasm or protoplasmic covering. The principal characteristics of this latter motion have already been given. This claim is, however, not advanced in the case of the discoidal forms, found adherent by countless thousands to marine algæ and the leaves of *Valisneria*, such as *Arachnoidiscus*,

Actinocyclus, *Coscinodiscus*, and *Biddulphia lævis*, which appear to pass their life cycle attached to water plants. But we also know that millions of the travelling frustules are removed from water plants which, when dried, exhibit the frustules in illimitable numbers, as may readily be determined from the mass of moss-like water plants sent herewith to the Society for distribution to such members as may desire to study them in the dry state.

Now, I would suggest that the character of the subjective motion of the protoplasm of the diatom possibly has its homologue in the cilia, pseudopodia, and other admitted protoplasmic appendages of the true Infusoria, and the Rhizopoda, and, in fact, the Protozoa generally; that is to say, in a contractile and extensile power common to the lowest forms of microscopic animal life. Since the activity of the protoplasmic sheath of the *Amphiprora ornata* is now clearly pointed out, it is within the range of verification by the simplest means. One is certain of witnessing a phenomenon that has for many years been of mysterious interest to observers. But there are two kinds of protoplasm, that of plants and that of animals. And the simplest in structure of the animal protoplasms is that associated with the Rhizopoda, which, barring the nucleus, are structureless, gelatinous masses, having an inherent extensile and retractile power, and presenting various modifications of outline. When employed in seeking their food, then their characteristics are best shown and appreciated.

Amœba proteus offers us protoplasm in one of its simplest conditions, that is, where it is devoid of the power of secreting a mineral covering, or even the rudiments of an internal skeleton. From this simple stage protoplasm passes through rising grades of complexity, ending in its power sometimes to secrete a chitinous covering, and sometimes a silicious shell or a shell built up of grains of silex. There is also the simple, structureless protoplasm of the Foraminifera, which is endowed with the power of secreting a shell from calcareous sources, and that of the sponge, which exercises the power of assimilating the molecules of carbonate of calcium or silica disseminated in the fluids of its habitat.

To further expand the relation between animal protoplasm and its peculiar power to secrete silica, I will offer my illustrations

from the domain of the Protozoa. I have consulted as many sources of information as the limited literary resources of my surroundings would admit.

First of all, possessing a copy of Joseph Leidy's "Rhizopods of North America," I consulted that for a portion of my data. In the said monograph is a general account of the classification of the Protozoa and their characteristics, as adapted from the greaf work of Prof. Haeckel. In this I find that, of the true Rhizopoda alone, the following species are characterized as having a protoplasm capable of secreting silicious shells, skeletal coverings, or external appendages—viz., *Euglypha alveolata* and *Euglypha olex; Clathuralina clegans; Acanthocystis* (minute silicious spicules); *Challengeria* (single-celled silicious organisms); *Acanthometrina* (having its spicules arranged in geometrical patterns, such as might be developed in a space of three dimensions, or on the surface of a sphere, and, owing to their extreme delicacy, collapsing or falling apart on drying and handling, and which were apparently only found in the material dredged by the *Challenger*); and also the *Thallasicola*, together with the numerous genera of the Radiolaria.

In connection with these I would refer to the fact that the peculiar open-meshed and stellate silicious skeletons known as *Dictyocha*, hitherto classed with the diatoms, likewise the forms called *Eucampia*, are stated in Wolle's "Diatomaceæ of North America" to be no longer regarded as diatoms, but are excluded therefrom. This dictum would relegate them to the Protozoa. But they are nearly always present in recent as well as fossil diatomaceous earths, as I have put upon record in the JOURNAL of the Society in some remarks upon a small *Navicula didyma* overlapping a *Dictyocha fibula* in the body of a *Coscinodiscus* from the Tampa fossil earth slide, filed with and donated to the Society. What expert diatomist will undertake to clear up the puzzle presented by the fifty or more discoidal forms on the same selected slide, exhibiting, either upon or through the internal structure of the diatom, hundreds of minute diatoms of many distinct species held therein? How did they get there, and why was the selection limited exclusively to the minutest of forms? Has any one, up to the noting of this peculiar characteristic of the discs of the Tampa marine fossil earth, made any observation of a similar con-

dition in the fossil deposits of any other known region of the globe? Notice also the power of the Foraminifera to secrete calcareous shells, and of the Spongidæ to secrete calcareous spicules, and we can infer that the animal protoplasm of the Protozoa has the power to elaborate out of their surrounding fluids the necessary shields or frames best adapted to their vicissitudes.

Against all of these positive and convincing data we can contrast nothing of an analogous kind in plant life. It would be useless to refer to the power of certain plants that flourish in ditches and marshes, and in tropical and semi-tropical regions, as the *Equisetaceæ*, or the canes, bamboos, and cereals, whose cuticular surface is a layer of vegetable silica. I believe that there is not any analogy between the power of the protoplasm of the Diatomaceæ to assimilate oxide of silicon as an integral part of its life, and the power of the plants named above to secrete whatever silica there may be in their woody structure; while there is abundant evidence of the animal protoplasm having in an eminent degree, and almost exclusively so, the power to appropriate from fresh or salt water the requisite silica needed in its life cycle.

But what has already been adduced does not reach the inferential bounds of the subject. Convictions often arise from fortuitous sources to round up a final conclusion. And as the diatomist accumulates fresh experiences year by year, he may group his facts in aiding him to some final conclusion or to reinforce some special view.

It is at this stage of the inquiry that the question comes up, Why is it that in nearly every known marine fossil diatomaceous deposit the silicious skeletons of the Diatomaceæ form the major part of the deposit, with few exceptions? The main exception is where the proportion of the diatoms in the deposit is less than the other fossil organic remains derived from the recognized rhizopods. What construction and interpretation are we justified in putting upon the fact that when we analyze any given fossil marine deposit we invariably find the following derivatives of the Rhizopods, viz., silicious Polycystinæ, or more properly Radiolaria, silicious sponge spicules, and silicious Diatomaceæ, together with calcareous foraminifera, invariably, or at least with few exceptions, associated in deposits of extraordinary thickness? Of two of these typical deposits I can justly claim that, at the

date of writing these notes, I am more familiar with two marine fossil deposits, discovered by myself, than any one else who has made the study of the diatoms a specialty. In one of these the Polycystinæ predominate above the Diatomaceæ, sponge spicules, and Foraminifera. This is the St. Stephens, Ala., eocene deposit, of which this Society possesses selected slides. Yet the diatoms are very abundant therein, and of many species. The other is the marine fossil deposit existing in the Florida phosphate rock area around Tampa, Fla., wherein the Diatomaceæ predominate above the Polycystinæ and silicious sponge spicules, and where calcareous Foraminifera seem to be entirely absent. The egg-shaped or ovoid silicious gemmules of sponges (?) are also very abundant therein. Taking an example right at hand, the world has been supplied with cleaned diatoms from the harbor clays and muds of Mobile Bay, in which are always associated diatoms, a few species of Polycystinæ, silicious sponge spicules, and rhizopods of several species, and more particularly the silicious shell-building ones known as *Difflugia pyriformis*, *Arcella*, and others. The silicious bodies called *Dictyocha* also abound, and the marine Foraminifera which secrete calcareous or chitinous shells. The mineralized calcareous cementstein of Sendai, Japan, and of the islands of Mor and Fur, situated off the northern coast line of Europe, when dissolved in acid, yield masses of Diatomaceæ, sponge spicules, and Polycystinæ, the diatom in the several cases predominating. The fossil diatomaceous clays of the Atlantic seaboard, from Southern New Jersey to Charleston, S. C., at Richmond and other points, always yield a small proportion of Polycystinæ in combination with a tenfold percentage of the Diatomaceæ. The fossil deposits of the Californian coast line yield diatoms in combination with Polycystinæ and sponge spicules, and so on *ad infinitum.*

Passing from the fossil marine deposits which I have put upon record, I will mention two extensive and rich deposits of fresh-water origin. First, the lacustrine fossil deposit at Montgomery, Ala., where billions of sponge spicules are associated with a stratum of diatom frustules over twenty feet in thickness and of extraordinary extension. Second, the marine marsh fluviatile deposit found by myself a year or so ago about a mile north of Mobile, on the western bank of Mobile River, which deposit is

characterized by the extraordinary richness of its diatoms, silicious sponge spicules, and billions of silicious rhizopod shells, *Difflugia* and other species.

At this point it might be appropriate to allude to a deposit situated at Montgomery, Ala.—the great artesian basin, about fifty feet in diameter and at least fifteen feet in depth. During a visit to Montgomery I observed that the basin was being cleaned out and that laborers wearing rubber boots were bailing out the ooze that had accumulated at the bottom, which ooze was at that time about eighteen inches deep and of about the consistence of gruel. Desiring to ascertain whether the ooze was a diatom ooze, I secured a quantity of the material and sent it to Mr. C. L. Peticolas, who sent me back beautiful slides of a pure gathering of *Epethemia gibba*. He remarked that it was the prettiest gathering he had ever seen of that species, and likewise the hardest to clean. Associated with the *Epethemia gibba* were a few species of smaller diatoms. This basin has been a feature of Montgomery, Ala., for over fifty years, and it is a remarkable fact that the basin held but one conspicuous species of diatoms through so many years.

As a last resort to defend the thesis that the Diatomaceæ ought to be regarded as belonging among the lower orders of animal life rather than among plant life, we can bring to our aid the established rules of the logician and of the mathematician ; the former granting the use of the syllogism, and the latter that of the "theory of probabilities," either of which I believe would force the solution of the question in favor of an animal status. The fact that the earliest algologists had classed certain genera of the filamentous diatomaceous groups among the Confervoideæ, such as *Melosira*, *Schizonema*, *Homeocladia*, *Mastogloia*, etc., on account of their algaceous habit, does not necessarily compel those to fall into line with their views who choose to regard all diatoms having a distinctive motive power and a motile protoplasmic sheath as belonging to the Protozoa.

Besides Leidy's excellent work, "Rhizopods of North America," I have consulted the able articles of various specialists in well-known encyclopædias, and I am under especial obligations to the paper of the eminent diatomist, Count-Abate Francesco Castracane, entitled "Generalita su le Diatomee" (1884).

I have also consulted the article by Prof. H. L. Osborn, entitled "The Protozoa—a Phyllum of the Animal Kingdom considered Biologically" (*American Monthly Microscopical Journal*, October, 1892), and the presidential address by Mr. Charles F. Cox, published in the JOURNAL of this Society, January, 1892. I have not had access to the recently published work of Messrs. Frederick W. Mills and Julien Deby, "An Introduction to the Study of the Diatomaceæ" (London and Washington, 1893), so that to this fact must be attributed any lack of acquaintance with the theories which may have been lately proposed.

Before closing I fain would refer to the use made by certain animals of the Diatomaceæ as a part of their food supply, with the view of determining whether the nourishment adapted to carnivorous animals is made up of microscopic plant protoplasm, either of what is called the ectosarc or endosarc of the Diatomaceæ. The most striking example within my own experience is that source of the Diatomaceæ derived from the gizzard or craw-like organ of the mullet of the Gulf bays From such gullets I have secured hundreds of pear-shaped pellets which were literally masses of pure diatoms, and of which I sent many in exchanges, both to foreign countries and also to Mr. C. L. Peticolas, of Richmond, Va., who returned to me at times beautiful preparations of the same. I have never found anything else but diatoms and sand grains in these fish gizzards, so this, as far as my experience goes, was the only food supply preyed upon by the mullet. I have also demonstrated that the desiccated excrementitious matter left by sea gulls on clusters of pilings in Mobile Bay has been a rich source of marine diatoms, after the undigested particles of fish bones, etc., are dissolved away with acid. As the diet of the sea gulls is principally fish, we can readily account for the presence of diatoms in such a recent source as the living sea gull. The stomach of the oyster sometimes yields diatoms, but the green masses found in the stomach are preferably marine algæ. The digestive tracts of the sea cucumbers—Holuthuriæ—have been justly celebrated for yielding immense numbers of marine diatoms. The trepang of the China Sea (which is dried abroad and sold in Mott street, New York, as a Chinese delicacy) is a sun-dried sea cucumber. From several sources we learn that in the Arctic and Antarctic regions

the Diatomaceæ float on the surface of the seas as a dense foamy sheet and are the sole food of some kinds of fish. The Abbé Castracane, already referred to, has written a special paper on the presence of the Diatomaceæ as the sole and exclusive food of *Echinus* and Echinodermata and Holothuriæ, dredged by the *Challenger* from depths of 2,000 and 5,740 metres. His object was to prove, contrary to common belief at that period, that plant life vegetated at a depth where the rays of the sun never penetrated. The fact of his finding rich masses of *Synedra thallassiotrix* Cleve. and *Coscinodiscus* in the Holothuriæ and Echini taken from these depths confirmed his belief. As the Abbé was a firm believer in the plant nature of the Diatomaceæ, he could not well do otherwise than regard this kind of food as plant life. He proved that the diatoms passed their life cycle at the bottom of the ocean, at 5.740 metres, on the feeding ground of the Echini and Holothuriæ, as the endochrome had not been removed by the digestive juices of the Echini or Holothuriæ after their removal by the dredge from their habitat at the bottom of the ocean, thus drawing another illustration of the use of the Diatomaceæ as a food supply.

I would note that at least four of the slides prepared from Mobile Bay brackish-water material, and sent herewith, show a number of rhizopods, *Euglypha alveolata*, within whose transparent and glass-like shells may be seen several varieties of very minute diatoms—viz., *Cocconeis pediculus* and *Naviculæ*. Also in a more pronounced manner, in the beautiful plates of Leidy's "Rhizopods of North America," various amœbæ are depicted at the moment of enveloping within their fluent protoplasmic layers large *Pinnulariæ* and other diatoms. And I have put upon record with this Society a selected slide of *Difflugia pyriformis* and other species, in which minute diatoms are seen to form a part of the solid shell covering the soft pseudopodial parts of the animal protoplasm when in its living state.

In the slides referred to above a pair of shells of *Euglypha alveolata* are mounted, showing the mouths of the shells in contact, or in the position usually regarded as that of conjugation. In the same slides will be noted an extraneous class of minute animals found in Mobile Bay—viz., minute shrimp, whose chitinous

cases have been turned a light hue of pink through immersion in balsam.

Before quitting the rhizopods I would make one more reference to an interesting feature that will have its application in summing up the consequences of these notes. I quote certain paragraphs in the article by Prof. Osborn, noticed above: "In its chemical nature the covering of *Hyalosphenia* is interesting, being *albuminoid* and less unlike the chemical nature of compounds in the protoplasm than are the skeletons of lime or silica found in *Ratalia* (foraminifera) *actinospherium* and many other specialized rhizopods. *It is, therefore, a less specialized act of the secretory power to produce a chitinous than a calcareous or silicious skeleton.*" And again: "*Liberkuhnia* is a naked body of rather definite outline, with one end prolonged into pseudopodia. The pseudopodia are never strictly radial, but are branching, the branches leading out into finer and finer divisions which often anastomose or join together. *The food is caught upon the network of pseudopodia and digested there.*" Or, in other words, we may put this interpretation on the concluding sentence, that an infinitesimal thread of protoplasm has a digestive, and as a consequence an assimilative, power. Can we not then inquire whether the living and moving protoplasmic layer of *Amphiprora ornata* has not an identical power, and is it not performing this digestive and assimilative function when it carries from point to point on its perimeter such particles as a motionless rotifer or a bacterium?

From the preceding restricted reference to animal life dependent on the Diatomaceæ, we are led to inquire whether an animal protoplasm would not be better associated with the idea of the sustenance of carnivorous animals, rather than that they should seek the sustenance of a purely plant protoplasm to build up and sustain their own changes of growth or waste.

This problem of the true nature of the sarcode of the Diatomaceæ is now respectfully submitted to those observers who care to take the pains to strive for a solution through observation, until no doubt shall remain as to what it is, whether absolutely plant or absolutely animal in its nature.

I would offer a few words explanatory of the contents of the six slides exhibiting the diatoms from the edge of Mobile Bay shore. They are prepared in duplicate, two of a kind, to show the

smallest species, the intermediate, and the largest discs. And the following genera are represented by from two to ten or more species each: *Achnanthes*, *Amphora*, *Amphiprora*, *Actinocyclus*, *Actinoptychus*, *Cocconeis*, *Cyclotella*, *Coscinodiscus*, *Campylodiscus*, *Cymbella*, *Epethemia*, *Eunotia*, *Gomphonema*, *Melosira*, *Nitzschia*, *Navicula*, *Odontidium*, *Pleurosigma*, *Steuroneis*, *Surirella*, *Synedra*, *Terpsinoe*, *Tabellaria*, the Naviculæ, however, being in the majority. In the observations of the living diatoms detailed herein I used a Zeiss D lens and at a magnification of about 600 diameters.

PROCEEDINGS.

Meeting of April 7th, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twelve persons present.

Mr. Noah Palmer was elected a Resident Member of the Society.

Dr. Samuel Lockwood, who was expected to deliver the address announced on the programme, was by illness prevented from attendance. An informal session was held.

Annual Exhibition, April 19th, 1893.

The Fourteenth Annual Exhibition of the Society was held at the American Museum of Natural History, Central Park, New York City, on the evening of April 19th, 1893.

Objects and apparatus, as noted in the programme below, were displayed in the large hall on the first floor of the Museum. At 9 o'clock Rev. E. C. Bolles, D.D., in the Lecture Room adjoining, gave an explanation of the projection of numerous microscopic objects on the screen.

PROGRAMME.

1. Water Wood-louse, *Asellus aquaticus*, showing the circulation of the colorless blood: by H. C. Bennett.
2. Section of Human Scalp, showing hair follicles, sebaceous glands, and ducts: by H. C. Bennett.
3. Transverse Section of a Cat's Tongue: by Wm. Wales.

4. Section of Soap Bark, *Quillaya saponaria*, showing long prismatic crystals: by G. H. BLAKE.

5. Sulphate of Copper, shown by polarized light: by N. PALMER.

6. Coal. Vascular Cylinder of a Young Stigmaria: by F. W. LEGGETT.

7. Head of Tape-worm, *Tænia solium*, showing the Rostellum and Suckers, with drawings of the same. Also specimens of the Head in alcohol: by L. SCHÖNEY.

8. Butterfly Scales and Diatoms arranged in the form of a Vase of Flowers: by G. S. WOOLMAN.

9. Transverse Section of the Head of a Moth, *Utetheisa bella*: by L. RIEDERER.

10. Longitudinal Section of the Antenna of a Wasp, *Vespa maculata*: by L. RIEDERER.

11. Transverse Section of the Head of a Fish, *Atherina*: by L. RIEDERER.

12. Transverse Section of the Body of a Fish, *Atherina*: by L. RIEDERER.

13. Microtome, manufactured by Aug. Becker, Göttingen, Germany: by L. RIEDERER.

14. Selection of Serial Sections: by L. RIEDERER.

15. Young of Marine Crustaceans: by E. J. RIEDERER.

16–18. Bacilli of Asiatic Cholera: by J. A. GOTTLIEB.

16. From a Culture in Bouillon, $\times$ 1,550.
17. From a Gelatin Culture, $\times$ 1,200.
18. Cultures in Nutrient Gelatin in Various Stages of Development.

19. Human Blood, $\times$ 590: by J. A. GOTTLIEB.

20. Blood of Seventeen-day Embryo Chick, $\times$ 480: by J. A. GOTTLIEB.

21. Frog's Blood (stained), $\times$ 330: by J. A. GOTTLIEB.

22. The Leitz Photomicrographic Apparatus: by J. A. GOTTLIEB.

23. Projection Apparatus, after Edinger: by J. A. GOTTLIEB.

24. Large Dissecting Microscope with Abbe's Camera Lucida: by J. A. GOTTLIEB.

25. Six Sections of Building Stones, shown on Automatic Re-

volving Stage by polarized light. Also specimens of the stones from which the sections were cut : by J. WALKER.

26. Polycystina : by J. WALKER.

27. Section of the Human Tongue : by C. S. SHULTZ.

28. Eggs of Various Insects, arranged : by C. S. SHULTZ.

29. Type Slide of Diatoms, arranged by D. B. Ward : by A. M. EDWARDS.

30. Circulation of Protoplasm (Cyclosis) in Nitella : by M. M. LE BRUN.

31. Young Codfish, one to three days old : by H. W. CALEF.

32. Transverse Section of the Leaf of the East India Rubber Tree, *Ficus elastica*, showing fibres, ducts, stomata, and cell tissue : by FREDERICK KATO.

33–36. Living and Pictorial Illustrations of Several of the Lower Forms of Animal and Vegetable Life : by STEPHEN HELM.

37. Pond Life : by A. D. BALEN.

38. Cinchonidine, shown by polarized light : by MISS M. V. WORSTELL.

39. Circulation of Protoplasm (Cyclosis) in Chara : by J. D. HYATT.

40. Ciliary Motion on the Gills of the Mussel : by J. D. HYATT.

41. Tongue of a Cricket : by W. D. MACDONALD.

42, 43. Pond Life : by H. C. WELLS.

44. The Curious Aquatic Insect, *Rheumatobates Rileyi* Bergroth, captured at Flatbush, L. I.; named by E. Bergroth, M.D., Tammerfors, Finland; and until recently the only reported specimen in the world : by J. L. ZABRISKIE.

45. Arranged Group of Diatoms, illuminated by parabola : by C. F. COX.

46. Crystals of Sugar, shown by polarized light : by C. F. COX.

47. Leaf of Deutzia scabra, showing stellate hairs : by W. E. DAMON.

48. Spines of Echinus : by H. G. PIFFARD.

49. Circulation of Blood in Tail of Tadpole : by F. W. DEVOE.

50. Circulation of Protoplasm in Vallisneria spiralis: by F. W. DEVOE.

51. File-tongue (*Odontophore*) of the New Jersey Conch, *Sycotypus canaliculatus*, with the shell: by SAMUEL LOCKWOOD.

52. File-tongue (*Odontophore*) of California Trochus, *Calliostoma canaliculatum*, with the shell: by SAMUEL LOCKWOOD.

53. File-tongue (*Odontophore*) of Patella, or Limpet Shell, *Acmæa testudinalis*, New England coast, with the shell: by SAMUEL LOCKWOOD.

54. Photomicrographic Apparatus: by F. D. SKEEL.

55–59. Star-fish and Sea-urchins, illustrated by living forms, microscopic specimens, and drawings: by G. W. KOSMAK.

60–66. Etchings of Steel Rails, showing Structure: by P. H. DUDLEY.

60. A .60% carbon Rail, with broad, shallow head. Dense structure.
61. A .45% carbon Rail, with deep head. Porous structure.
62. A good wearing Rail, made in 1863.
63. A rapid wearing Rail, made in 1880.
64. Nickel Armor Plate.
65. Specimens of Tests of Armor Plate, Ordnance, and Rail Steel.
66. Photographs of Drop Tests of a .60% Carbon Rail, etc.

67, 68. Sections of Silicified Wood, *Araucaria Briggsii*, from Arizona: by T. B. BRIGGS.

67. Transverse Section.
68. Radial Section.

69. Section of Wood, *Araucaria excelsa*, from Norfolk Island: by T. B. BRIGGS.

70. Platino-cyanide of Yttrium, shown by polarized light: by E. G. LOVE.

71. Seeds of Orthocarpus purpurascens: by E. G. LOVE.

72. Pollen of Mallow, *Malva rotundifolia:* by E. G. LOVE.

73. Foot of Spider: by E. G. LOVE.

74. Photomicrographs: by E. G. Love.

75. Pond Life: by W. C. KERR.

76. A Living Diatom, *Bacillaria paradoxa:* by T. CRAIG.

77. Hydra viridis: by J. C. Thompson.
78. Circulation in Frog's Foot: by J. C. Thompson.
79. Pond Life: by O. H. Wilson.
80. Circulation of Protoplasm in the Skin of the Onion: by M. Dupuy.
81. Colored Drawings of Microscopic Objects: by M. Dupuy.
82–86. Microphotographs, selected: by S. N. Ayres.
87. Fossil Vegetable Structure in Coal Shale: by Geo. E. Ashby.
88. Section of Stalactitic Chalcedony, shown by polarized light: by J. W. Freckelton.
89. Desmids: by E. J. Wright.
90. Quartz Inclusions in Mica, shown by polarized light: by A. H. Ehrman.
91. Microphotograph of Niagara Falls: by H. Fincke.
92. California Gold Sand: by H. Fincke.
93. Arranged Diatoms: by H. Fincke.
94. Nitroprusside of Sodium, shown by polarized light: by H. Fincke.
95. Section of Malacca Cane from Malay Peninsula: by A. Woodward.
96. Ash Block containing Living Termites, *Calotermes flavicollis*, taken at the Isthmus of Panama, August, 1890: by J. Beaumont.
97. Specimen of Termite Tree Nest, *Termes minimus* Beaumont, with alcoholic specimens of queen, soldiers, and workers: by J. Beaumont.
98. Cultivation, Staining, and Mounting of Bacteria: by P. H. Lyon.
99. Circulation in the Tail of a Gold-fish: by W. H. Mead.
100. Tooth of Fossil Fish in Coal: by The Society.

Meeting of April 21st, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Fourteen persons present.

Dr. Frank Abbott, Jr., was elected a Resident Member of the Society.

On motion the thanks of the Society were tendered Mr. Morris K. Jesup, President of the Board of Trustees, and the Officers of the American Museum of Natural History, for their kindness in granting the use of the Halls of the Museum, and for their generous assistance in the matter of the late Annual Exhibition of the Society.

OBJECTS EXHIBITED.

1. Gas carbon filaments, deposited on the edge of a burner: by E. G. LOVE.

2. Diatoms from the Bay of Bengal: by H. C. BENNETT.

3. Section of Cementstein from Sendai, Japan: by H. C. BENNETT.

4. Living diatoms: by C. S. SHULTZ.

MEETING OF MAY 5TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Sixty persons present.

Dr. George M. Sternberg delivered the address announced on the programme, entitled "Bacteria." This address was most admirable for its comprehensiveness and its perspicuity, and was beautifully illustrated by a most remarkable series of lantern projections.

On motion the hearty thanks of the Society were tendered Dr. Sternberg.

MEETING OF MAY 19TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-four persons present.

Dr. Samuel Lockwood addressed the Society on "Some Phenomena in Exuviation by the Reptiles." This address was illustrated by specimens and objects under microscopes, as noted in the programme below, and is published in this volume of the JOURNAL, page 55.

OBJECTS EXHIBITED.

1. Bronze, life-size representations of Snake, Lizard, and Frog.

2. "Scarf" of Anaconda.

3. Skin of the Lizard, *Anolis principalis*, under a $\frac{1}{5}$ objective, showing "the windows."

4. Skin of the Horned Toad, *Phrynosoma cornuta*, under a $\frac{1}{5}$ objective, showing pigment grains.

Exhibits Nos. 1-4, inclusive, were by SAMUEL LOCKWOOD.

5. Photomicrograph, half-tone print, of scale of Podura, *Lepidocyrtis curvicollis*, × 3,000: by H. G. PIFFARD.

6. Photomicrograph of pygidium of Flea, taken by Dr. Henri Van Heurck, who regards this object as a test, second in value only to the Podura scale: by H. G. PIFFARD.

7. Various Diatoms: by NOAH PALMER.

Some points on the changeability in color of the skin of the Chameleon, in Dr. Lockwood's address, were discussed by Messrs. J. D. Hyatt, L. Riederer, and W. J. Lloyd. Mr. Riederer suggested that the changeableness may be somewhat on the principle of "Newton's rings," since there are two films in the skin of the chameleon.

MEETING OF JUNE 2D, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-four persons present.

Dr. H. G. Piffard read a paper entitled "An Improvement in the Correction of Lenses for Photomicrography, Photography, and Photoastronomics." This paper was illustrated by many photomicrographs, as cited below.

OBJECTS EXHIBITED.

1. Watson's Van Heurck Stand: by H. G. PIFFARD.

2. *Navicula rhomboides*, under a William Wales $\frac{1}{10}$, made eighteen years ago: by H. G. PIFFARD.

3. The same; resolution of "beads," with parabola: by H. G. PIFFARD.

4. Podura scale: by H. G. PIFFARD.

5. Photomicrographs: blood of *Amphiuma*, *Echinus* spine, probe platte, histological section, Podura scale, *Amphipleura pellucida*, *Limulus*, copy of a painting, street scene, interior view: by H. G. PIFFARD.

6. *Amphipleura pellucida*: by HENRY C. BENNETT.

7. Probe platte by Möller: by HENRY C. BENNETT.

8. Photomicrographs: *Amphipleura* × 1,500, *Pleurosigma angulatum* × 6,000, section of human eye: by F. D. SKEEL.

9. *Frustula saxonica*, $\frac{1}{10}$ homogeneous immersion lens and vertical illuminator: by CHARLES S. SHULTZ.

MEETING OF JUNE 16TH, 1893.

The Vice-President, Dr. E. G. Love, in the chair.

Dr. F. D. Skeel was elected Secretary *pro tem.*

Surgeon-General George M. Sternberg, U. S. A., was elected an Honorary Member of the Society.

Dr. E. G. Love, chairman of the Committee on Annual Exhibition, reported for the Committee, and the Committee was discharged with thanks.

OBJECTS EXHIBITED.

1. According to previous appointment, the entire collection of "Jackson Slides," recently purchased by the Society, were exhibited in succession.

2. Photomicrographs of *Triceratium favus* × 1,500, and of *Pleurosigma angulatum* × 750 and 6,000: by FRANK D. SKEEL.

The Society adjourned to the first Friday of October, 1893.

PUBLICATIONS RECEIVED.

American Monthly Microscopical Journal: Vol. XIV., Nos. 2—9 (February—September, 1893).

The Microscope: Vol. I., Nos. 2—10 (February—October, 1893).

San Francisco Microscopical Society: Proceedings (April 9—March 1, 1893); Transactions, Part I. (1893).

Bulletin of the Torrey Botanical Club: Vol. XX., Nos. 3—10 (March—October, 1893).

Insect Life: Vol. V., Nos. 4, 5 (April, July, 1893).

Psyche: Vol. VI., Nos. 204—211 (April—November, 1893).

The Observer: Vol. IV., Nos. 1—10 (January—October, 1893).

Proceedings of the Natural Science Association of Staten Island: Index of Vol. II. (November 10, 1888—October 10, 1891); Meetings (March 18—October 14, 1893).

Anthony's Photographic Bulletin: Vol. XXIV., Nos. 5—21 (March 11—November 11, 1893).

School of Mines Quarterly: Vol. XIV., Nos. 2—4 (January—July, 1893).

American Museum of Natural History: Annual Report (1892).

New York Academy of Sciences: Index of Vol. XI. (1892); Transactions, Vol. XII. (1892, 1893).

Proceedings of the American Academy of Arts and Sciences: Vol. XXVII. (1892).

Proceedings of the Boston Society of Natural History: Vol. XXVI., Part I. (November, 1892—May, 1893).

Proceedings of the Academy of Natural Sciences of Philadelphia: 1893, Parts I. and II.

Bulletin of the Museum of Comparative Zoölogy at Harvard College: Vol. XXIV., Nos. 6, 7—Vol. XXV., No. 1 (July—September, 1893).

Journal of the Franklin Institute: Vol. CXXXV., No. 807—Vol. CXXXVI., No. 815 (March—November, 1893).

Transactions of the Massachusetts Horticultural Society: Part II., 1892; Part I., 1893.

Journal of the Elisha Mitchell Scientific Society: Vol. IX., Part II. (1892).

Transactions of the Connecticut Academy of Arts and Sciences: Vol. VIII., Part II.; Vol. IX., Part I. (1893).

Report of the Missouri Botanical Garden (1893).

United States Geological Survey: Eleventh Annual Report, Parts I. and II. (1889—90).

Proceedings of the Rochester Academy of Science: Vol. II., No. 2 (1893).

Bulletin of the Essex Institute: Vol. XXIV., No. 7—Vol. XXV., Nos. 1—6 (July, 1892—June, 1893).

Journal of the Cincinnati Society of Natural History: Vol. XV., No. 3—Vol. XVI., No. 3 (October, 1892—October, 1893).

Cornell University Agricultural Experiment Station, Bulletins: Nos. 50—57 (March—September, 1893).

Bulletin of the Michigan Agricultural Experiment Station: Nos. 90—99 (February—July, 1893).

Bulletin of the Iowa Agricultural Experiment Station: Nos. 20, 21 (1893).

Bulletin of the Alabama Agricultural Experiment Station: Nos. 41—47 (December, 1892—July, 1893).

Bulletin of the Texas Agricultural Experiment Station: No. 26 (March, 1893).

Bulletin of the Division of Entomology, U. S. Department of Agriculture: Nos. 29, 30 (1893).

Colorado Scientific Society: Six pamphlets (1893).

Journal of the Royal Microscopical Society: Parts II.—V. (1893).

International Journal of Microscopy and Natural Science: Vol. III., Nos. 18—20 (April—October, 1893).

Journal of the Quekett Microscopical Club: Vol. V., No. 32 (July, 1893).

Manchester Microscopical Society: Transactions and Report (1892).

The Naturalist: Nos. 212—220 (1893).

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